PD-AAN-728
XD-AAN-728A
ISN-33077

UNCLASSIFIED

CLASSIFICATION

PROJECT EVALUATION SUMMARY (PES) – PART I

Report Symbol U-447

1. PROJECT TITLE: CRSP – Sorghum-Millet

2. PROJECT NUMBER: 931-1254 / 15

3. MISSION/AID/W OFFICE: S&T/AGR/AP

4. EVALUATION NUMBER (Enter the number maintained by the reporting unit e.g., Country or AID/W Administrative Code, Fiscal Year, Serial No. beginning with No. 1 each FY): 83-12

Team Evaluation

☐ REGULAR EVALUATION ☐ SPECIAL EVALUATION

5. KEY PROJECT IMPLEMENTATION DATES

A. First PRO-AG or Equivalent FY 79

B. Final Obligation Expected FY Cont.

C. Final Input Delivery FY cont.

6. ESTIMATED PROJECT FUNDING

A. Total $ 14,500,000

B. U.S. $ 14,500,000

7. PERIOD COVERED BY EVALUATION

From (month/yr.) Jan. 1981

To (month/yr.) Feb. 1982

Date of Evaluation Review

8. ACTION DECISIONS APPROVED BY MISSION OR AID/W OFFICE DIRECTOR

A. List decisions and/or unresolved issues; cite those items needing further study. (NOTE: Mission decisions which anticipate AID/W or regional office action should specify type of document, e.g., airgram, SPAR, PIO, which will present detailed request.)	B. NAME OF OFFICER RESPONSIBLE FOR ACTION	C. DATE ACTION TO BE COMPLETED
1. Revise sub-projects in accordance with recommendations of the Technical Committee and approved by the Board of Directors	Principal Investigators	November 1982
2. Re-examine certain projects to determine their applicability to removing constraints to sorghum/millet production and consumption.	CRSP/TC	January 1983
3. Assure ICRISAT representatives attend EEP reviews	CRSP/ICRISAT	Continuing
4. Review feasibility of changing method of review to delve more deeply into some particular aspects of the work rather than reviewing all aspects in conjunction with the EEP activities	CRSP ME	January 1984
5. Review feasibility of eliminating annual review requirement as stipulated in the Grant Agreement. The extensive evaluation could coincide with the AID/EEP Triennial indepth review.	AID/CRSP/BIFAD	March 1984

9. INVENTORY OF DOCUMENTS TO BE REVISED PER ABOVE DECISIONS

☐ Project Paper ☐ Implementation Plan e.g., CPI Network ☐ Other (Specify)

☐ Financial Plan ☐ PIO/T

☐ Logical Framework ☐ PIO/C ☐ Other (Specify)

☐ Project Agreement ☐ PIO/P

10. ALTERNATIVE DECISIONS ON FUTURE OF PROJECT

A. ☐ Continue Project Without Change

B. ☐ Change Project Design and/or

☒ Change Implementation Plan of certain sub-grants

C. ☐ Discontinue Project

11. PROJECT OFFICER AND HOST COUNTRY OR OTHER RANKING PARTICIPANTS AS APPROPRIATE (Names and Titles)

S&T/AGR/AP:RIJackson for GWV Date 10/18/47

S&T/AGR/AP:JYohe [signature] Date 10/19/47

S&T/AGR:MMozynski [signature] Date 10/20/83

12. Mission/AID/W Office Director Approval

Signature [signature]

Typed Name Alison R. Bertrand

SUMMARY

13. This Collaborative Research Support Program for Grain Sorghum/Pearl Millet (CRSP-S/M) was evaluated by the External Evaluation Panel (EEP) during the week of September 15-19, 1980 and again during the week of February 1-5, 1982. This PES will address the period between September 1980 and February 1982. The EEP met the second time with the Board of Directors, Technical Committee and Prinicpal Investigators at Kansas City, Mo. During this review, the entire CRSP was examined. Day 1 was devoted to examination of the linkages wth the LDCs and IARCs; days 2 and 3 were spent in reviews of each individual project, organized by the seven discipline groupings. Country and discipline coordinators arranged the individual presentations. Each project leader presented results in a brief written summary and also orally. Opportunity was given for EEP members to ask questions and discuss results.

The bases for this evaluation are: Report of External Review Panel (Attachment A); and Summary of actions taken by the CRSP-S/M Technical Committee and Board of Directors in response to the EEP review (Attachment B). The Technical committee's recommendations to the Board of Directors were approved by the Board. The latter instructed the Committee to inform the Principal Investigators (PRs) of these decisions and to take the steps necessary to conform to these recommendations. These entailed re-examining a few projects more closely to determine the applicability of these projects to removing constraints to sorghum/millet production and consumption in the LDCs. These recommendations are discussed in more detail under Inputs below.

14. EVALUATION METHODOLOGY

The Grant Document contains the following:

"The Grantee (ME) agrees to establish an External Evaluation Panel for guidance, appraisal and recommendations relative to this CRSP. The Panel shall consist of individuals from institutions other than those receiving funds under this grant, and shall include the mix of disciplines necessary to carry out the above assignments. Membership shall be approved by the BIFAD."

"The Panel shall conduct appraisals of the program either annually, or at strategtic accomplishment target dates. The appraisals shall assess the adequacy of program plans, especially relationships amongst components carried out by different institutions, and shall make in-depth reviews of progress by individual institutions and by the program as a whole. At the conclusion of each appraisal, or more frequently if considered appropriate, written reports of evaluations of this CRSP will be submitted to the Grantee, to the Collaborating institutions and to A.I.D."

"Annually, after submission of the Grantee's report, this grant shall be reviewed jointly by the Grantee, BIFAD and A.I.D."

At the EEP's review in February 1982 at Kansas City, Missouri, all the PIs presented a short paper describing the individual projects and the accomplishments to date (Attachment C). The Panel largely based its report on these presentations and the discussions following each PI's paper. This review was in keeping with the Grant Document's provision outlined in the first paragraph of this section.

15. EXTERNAL FACTORS

The CRSP-S/M is made up of 41 projects at eight U.S. Land Grant universities. All of these projects were funded by the later part of CY 1979. Only one institution was denied funding for year 4, Florida A&M. Two projects were terminated as a result of Board action, one at Purdue and one at Kansas State.

The EEP's Report of the Second CRSP-S/M Review (Attachment A) were examined in detail by the Technical Committee at its meeting on February 19, 1982. The Committee went over the EEP's Review and made recommendations for necessary/corrective action to the Board of Directors. Based upon extensive discussions of these projects and the Panel's review (Attachment A), the Committee made specific recommendations to the Board of Directors. These recommendations were concurred with by the Program Director and approved by the Board of Directors. The Program Director has taken the necessary steps to inform the Principal Investigators of any changes to be made as a result of the Board of Directors' approval.

16. INPUTS

The EEP made note of the fact that the sorghum program leader, Dr. Lee House, and the millet program leader, Mr. David Andrews, both from ICRISAT were able to attend the review. It was also noted that one or two senior professional staff members from ICRISAT should always be present at future review meetings.

The panel also suggested that the Program Director of the CRSP and the Technical Committee may wish to consider possible alternative ways of conducting future reviews such as a more informal sharing and exchange of ideas and experiences which may prove of greater value than the present mode of review. It was further suggested that rather than reviewing all of the projects of the CRSP, it might be better to delve more deeply into some particular aspect of the work at each review.

It was also mentioned that the Board of Directors may wish to consider the interval of time which should elapse between reviews. Annual meetings may be too frequent. It is anticipated that this suggestion will be implemented in the near future when the EEP review and the A.I.D. review are held simultaneously.

The EEP was most favorably impressed by the progress made by the CRSP scientists between the first and second reviews. It was stated in the review that it was appreciated the way in which suggestions made in the first report were examined and acted upon.

17. OUTPUTS

The Panel believed that this CRSP is making a valuable and distinctive contribution towards meeting the needs of the developing world. Its primary purpose is being achieved effectively by making available to the agricultural scientists of the developing world the knowledge, skills and personal concern of the sorghum/millet scientists of the U.S. universities. The flexibility under this CRSP allows each participationg institution group to make effective arrangements to meet the needs of the individual countries and organizations where programs are being implemented.

The current situation of development of international linkages includes the following countries:

Botswana	Mali (S/M CRSP; Soil CRSP)
CIAT/Colombia	Mexico
Egypt	Niger (Entom. assist. to ICRISAT subctrs.)
Honduras	Upper Volta
ICRISAT/India	Sudan
IRRI/Philippines	Tanzania

There are many other linkages through student training, both in the U.S. and LDCs, and visits of CRSP principal investigators. These have been increasing each year under this CRSP and it is anticipated that these linkages will continue to increase, but level off soon because of funding constraints.

Technical outputs achieved under this CRSP during the review period have been:

a. SOCIOECONOMIC

The University of Kentucky project is in its final stages of completion in the Sudan. The information generated from the analysis of this project should provide useful information for the other scientists associated with the CRSP. The review of the research policy should likewise provide useful information to help understand the institutional environment within which the scientists must act.

The Kansas State University project in India has been terminated and the final report of this study is expected soon. It was pointed out by the EEP that the results of this study are not likely to contribute significantly to general CRSP objectives.

The Purdue University project in West Africa on the synthesis of available socioeconomic information relating to agriculture in the Sahelian countries is well underway. Cataloging of the studies and publications collected provide a valuable information source of benefit to the Sahelian countries.

Research on market development and price policy is of top priority. The EEP suggested the focus of this project should be encouraged and extended to other geographic regions.

b. AGRONOMY

The University of Nebraska has stationed a scientist in the Philippines for a year ending in June 1983 to work on mineral element efficiency improvement with emphasis on nitrogen uptake and use. Unfortunately no U.S. scientist has been found to continue this work at this time.

The millet stand establishment project is essential and is relevant only to the LDCs. This project is carried out by Kansas State and the Panel felt that most of the research should be done in the LDCs.

Mississippi State has a project on seed factors influencing stand establishment of sorghum. The EEP thought this project may be too technical for practical application.

The University of Nebraska's project in Tanzania with emphasis on genotype X environment interaction with regard to farming systems has special implication to experiment station development and/or improvement.

c. PLANT PHYSIOLOGY

The University of Nebraska has taken the lead in this discipline with four projects. One emphasizes temperature, yield and water stress interactions which are significant in much of the world in relation to sorghum and millet production. A second one on water relations is sound, but could use international linkages which will require less sophistication and an ability to handle a much greater number of lines. A third one on climatology should involve overseas linkages with such countries as the Philippines, Tanzania and Colombia.

The Arizona project involves both screening service of the breeder as well as traits of parents and hybrids. The uniqueness of the environment makes this a strong program for both U.S. training as well as international linkages.

d. PLANT BREEDING

The work on drought resistance at the University of Arizona is extremely important for most of the LDCs growing sorghum and millet. The testing and evaluation of elite germplasm selected at LDC sites where drought is a major problem will strengthen linkages with these LDCs.

Kansas State has the only project on the important area pearl millet breeding. The germplasm developed under this project should be useful for areas with short seasons.

Texas A&M's project is excellent and probably the best example of work most useful and applicable to the LDCs. The germplasm coming out of this project continues to be in high demand both in the LDCs and the U.S. This is an excellent project to serve the needs of the LDCs.

A second project at Texas A&M is breeding for disease resistance which has been oriented toward the needs of the LDCs and which has developed good linkages with the LDCs.

A third Texas A&M project parallels the second one in breeding for insect resistance. This project continues to develop germplasm of use to many countries in the semi-arid tropics.

e. UTILIZATION AND NUTRITION

Purdue's project is providing useful information on the nutritional problems in sorghum and the effects of processing on nutritive value.

A second project at Purdue deals with the tannin content which represents one of the main limiting factors in sorghum utilization and its effects on nutritive value.

The project at Texas A&M is providing valuable information on utilization of sorghum as food, alone or in combination with other foods. The information is of value in developing countries and more effort should be made to implement the various technologies developed.

f. PLANT PATHOLOGY

One of the outstanding projects of the CRSP is plant pathology at Texas A&M which provides services to and consultations with LDC scientists for the development of educational information, the establishment of a network of international disease nurseries, the holding of conferences and workshops, training and education of a large number of students on campus and the development of a number of overseas linkages. The development of multiple disease resistant, food cultivars in cooperation with breeding projects are applicable to LDCs. collateral to this is the establishment of and transmission to LDCs of disease testing procudures.

The project at Purdue on diseases has been totally revamped to emphasize anthracnose of sorghum. The EEP suggested that there should be strong cooperation established with breeding projects.

g. ENTOMOLOGY

The Texas A&M project in entomology is similar in output to that in pathology. It is a model example of how a project should function and shares most of the characteristics and workshops, consultancy services, supply of pertinent information and interdisciplinary research work. There has been a good linkage established with ICRISAT. With this linkage, the important insect pests of the world can be dealth with in an orderly manner.

Kansas State has the only CRSP project dealing with storage and preservation of pearl millet grain. This subject is of importance to the LDCs.

18. PURPOSE

The purpose of this CRSP is to:

a. Organize and mobilize financial and human resources necessary for mounting a major, multi-institutional U.S.-LDC collaborative effort which in turn is expected to provide the knowledge base necessary to achieve significant advances in alleviating the principal constraints to improved propduction, marketing, and utilization of grain sorghum and pearl millet in LDCs

b. Improve the capabilities of appropriate LDC institutions to generate, adopt and apply improved knowledg on grain sorghum and pearl millete to local conditions.

At the time of this review, the CRSP has been operational for about 3 years. The final form of its activities is not in place. This is particularly true of the activicies in LDCs and at international agricultural research centers.

It should be noted that this CRSP has been underway such a short time prior to this review that there has been only limited opportunities for any major research accomplishments.

19. GOAL

The major goal of this CRSP is to increase production of grain sorghum/pearl millet in those countries where they are the principal crops. This is to be achieved by:

- Developing and testing new and improved technologies;

- Teaching local scientists to solve problems related or sorghum/millet production and use.

As stated above, prior to this review, the project was in the implementation stage for such a relatively short time that it is too early to comment on the progress of the CRSP other than to mention that research on the two crops has been initiated and early indications from the principal investigator are that the various programs are moving progressively toward the goal.

20. BENEFICIARIES

The ultimate CRSP beneficiaries are producers and consumers of grain sorghum and pearl millet in the LDCs. Producers are expected to benefit through improved production methodologies by reducing the possibilities of crop failure, increasing crop yield and decreasing the costs of production which will result in improved subsistence and income for the producers. Consumers are expected to benefit through:

- More reliable supplies of these food grains at stable prices in the market place, and;

- Availability of food grains that are more nutritious and with desirable taste, color and digestibility characteristics.

21. UNPLANNED EFFECTS

Not pertinent at this time.

22. LESSONS LEARNED

Social scientists can play several roles including: 1) baseline studies at the initial stage of project preparation; 2) marketing studies to determine what must be done to promote economic incentives; 3) production-economic studies; 4) policy studies; and 5) broad analyses to project demand and supply.

The EEP felt that the agronomy projects have the capability to bring scientific accomplishment to the LDC farmers.

The panel expressed its concern as to the applicability of some of the plant physiology projects to ongoing research in the LDCs.

The panel reported that this CRSP is already making a valuable and distinctive contribution towards meeting the needs of the developing world. Its primary purpose of transferring scientific and technical data to LDC agricultural scientists is being achieved effectively. The flexibility under this CRSP allows each participating U.S. institution to make effective arrangements to meet needs of the individual countries and organizations where assistance is being given.

23. SPECIAL COMMENTS OR REMARKS

The following documents are attached:

Attachment A - Report of External Evaluating Panel. This is the Panel's Report to the Board of Directors of the CRSP.

Attachment B - Summary of Actions Taken by INTSORMIL (CRSP) in Response to External Evaluation.

Attachment C - Individual Project Reviews Presented by the Principal Investigators.

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Attachment A

INTSORMIL
EXTERNAL EVALUATION PANEL REVIEW
Kansas City, Missouri
February 1-5, 1982

Report of the Second INTSORMIL Review

Acknowledgements

1) We are grateful to the Board of Directors, to the Director of INTSORMIL, and to the Technical Committee for their strong interest, co-operation and assistance, both in the preparation for this review, and during the review itself. We noted with appreciation the way in which the members of the Board, as well as the Director, Dr. Earl Leng, attended all the sessions, taking an active interest in the daily proceedings, and discussing the programs and many of the issues raised.

2) We are grateful to the scientists who outlined their work to us for the high standard of their concise presentations, and for all the time put in on preparation. Their efforts were of great value to our panel.

A. General

3) Five members of the panel were present for this review. Dr. Uma Lele was unable to attend, so Dr. Ralph Cummings, Jr. kindly agreed to act as the sixth panel member. The presence of Dr. Ricardo Bressani added another voice from the developing world to that of Dr. Brhane Gebrekidan, and his eminence in the field of nutrition and food science ensured a better assessment of those aspects of the program than was possible at the earlier review. Similarly, Dr. Cummings' contribution to the socio-economic area was invaluable.

4) We were glad that the sorghum program leaders, Dr. Leland R. House, and the millet program leader, Dr. David Andrews were able to attend from ICRISAT. We found their presence essential, and would urge that one or two senior professional staff from ICRISAT should always be present at these review meetings. The possibility of inviting the ICRISAT sorghum and millet physiologists to the next meeting should be considered. They might be encouraged to spend a few days in professional discussions with the university plant physiologists involved in projects under this CRSP. We recommend that the Director be empowered to invite sorghum/millet workers not presently being supported from INTSORMIL funds to attend these meetings. Dr. Bob Jackson of USAID and Dr. W. Fred Johnson, representing BIFAD, participated in all the meetings. Their constructive contributions are acknowledged with appreciation.

5) The Director of INTSORMIL and the Technical Committee may wish to consider possible alternative ways of conducting these reviews. Now that the CRSP is operational we believe that a more informal sharing and exchange of ideas and experiences would be of greater value. We are required to review the whole operation of the CRSP, but it may be better to go more deeply into some particular aspects of the work at each review, rather than trying to deal with the whole program in depth on every occasion.

6) The Board may also wish to consider the interval of time which should elapse

between reviews. Annual meetings may well be too frequent now that such an excellent start has been made.

7) At the time of this review, the CRSP had been operational for 25 months. We are most favorably impressed by the progress made since the earlier review 16 months ago. We are delighted by the speed and imaginative ways in which the overseas linkages have been created. We appreciate the way in which the suggestions made in our last report have been examined and acted upon. An excellent beginning has been made.

8) We believe that this CRSP is already making a valuable and distinctive contribution towards meeting the needs of the developing world. Its primary purpose of making available to the agricultural scientists of the developing world the knowledge, skills, and personal concern of the scientists of the U.S. Universities is being achieved effectively. We particularly welcome the constant thought being given to finding new and better ways of achieving this end. The flexibility under this CRSP allows each University group to make effective arrangements to meet the needs of the individual countries and organizations where assistance is being given.

Overseas Linkages

9) Overseas linkages were considered in paragraphs 21, 22 and 23 of our last report, to which reference should be made.

10) The current situation of development of international linkages includes the following countries:

COUNTRY	# OF PROJECTS	COUNTRY	# OF PROJECTS
Botswana	1	Mali	2
Colombia	2	Mexico	2
Egypt	2	Niger & Upper Volta	2
Honduras	5	Philippines	1
ICRISAT	2	Sudan	3
India	1	Tanzania	1
IKRI	1		

11) There are many other linkages through student training and visits by INTSORMIL scientists, who spent 1,813 days visiting LDC's, or approximately seven scientists years in the past year.

FINANCIAL

Project fund allocations of AID support for the 1981-82 year 3 and for 1982-83 years 4 are as follows:

INSTITUTION	NUMBER OF PROJECTS	AID CONTRIBUTION Year 3(000)	Year 4(000)
Arizona	1	70	75
Florida A&M	1	29	--
Kansas State	6	366	415
Kentucky*	2	200	120
Mississippi State	3	255	300
Nebraska	9	410	495
Purdue	5	435	435
Texas A&M**	7	745	805
Management Entity: Headquarters		200	300
Technical Assistance		40	100
LDC's		100	355
	TOTAL	2,850	3,400

*includes a Sudan and a Honduras project

**includes Honduras project

Continuity of funding is essential for this CRSP to function at a high level of expertise and was to be assured by this grant being extended annually to maintain a five-year advanced program plan.

For Year 4, INTSORMIL has presently $1,858 million and expects to receive on May 1 or earlier $1,642 million. This will give the full $3.5 million for year 4 (July 1, 1982-June 30, 1983). Expected expenditure as above is 3.4 million.

The INTSORMIL grant calls for $3.5 million more for year 5. AID now proposes to give only $3.1 million, whereas projects expect to spend $3.6 million.

For year 6, there is need for $4.25 million AID money but here again, AID proposes only $3.1 million. For year 7, $4.79 million is needed.

This significant reduction for years five and six can only reduce the effectiveness of a rapidly expanding international component of sorghum and millet improvement for the LDC's. The review committee strongly urges AID support of the amounts suggested above of $3.6 million for year 5 and $4.25 million for year 6 which in fact represents no increase over year four assuming 10% inflation.

Continuity of funding is absolutely essential. The director has committed funds to place and maintain certain staff members overseas, to ensure that the maximum amount of work is done in the developing world, as required under the legislation establishing the CRSP. This involves firm financial long-term commitments, and the maximum possible proportion of the budget has been committed in

this way. Any failure to fulfill the complete funding obligations already entered into by AID would do serious damage to the program and such injury could be permanent. The resultant uncertainty and sense of insecurity in the minds of those staff posted overseas would lead to unwillingness on the part of other high caliber staff to enter into commitments for overseas service.

THE INTSORMIL ESTABLISHMENT

ORGANIZATION:

We consider that the organization established by the Director is working well. The headquarters cell staff has been kept to the minimum. We welcome the appointment of a part-time Assistant Director to help the Director with his substantial work load. We note that the Assistant Director will be especially involved with the operations in Botswana. We consider that this appointment was essential. The Technical Committee system has proved to be very successful in operation.

PARTICIPATING UNIVERSITIES:

The Director has informed us that there are no advantages either administratively or costwise to be gained from reducing the number of participating universities. The skills and expertise in sorghum and millet available in the U.S.A. are distributed over many universities. We believe that all willing and able to participate effectively should be encouraged to do so, as circumstances permit. A much wider pool of skills is then available than could be the case were the CRSP operations to be confined to two or three universities. We welcome the intention to include the University of Georgia under this CRSP, and believe that any reduction in the number of universities for reasons of administrative tidiness alone would deny the services to this CRSP of many talented people.

LATIN AMERICAN PROGRAMS:

We noted with approval the steps taken to develop INTSORMIL activities in Latin America:

Mexico/CIMMYT:

Recognition is given to the successful disease workshop recently held in Mexico for extension-type participants from Mexico and Central American countries. Also cooperative research with Dr. Vartan Guiragossian with ICRISAT at CIMMYT, where research having implication for Latin America is encouraged. Because of the impact of the commercial seed business in Mexico represented by every major U.S. sorghum company we would discourage INTSORMIL sorghum breeding activities at country level. The opportunity for Mexico to be self-sufficient in coarse grain production will most likely occur by a strong commercial seed industry encouraged and supported by the Mexican government. At present, more than 90% of the sorghum acreage is hybrid and 95% of the hybrid seed is provided by private industry. Any agreement with the government of Mexico must make hybrid seed produced under the INTSORMIL program freely available to all, especially to the private seed companies.

Honduras:

Developments in Honduras are most satisfactory. Several projects are in operation, and an agronomist from Texas who is fluent in Spanish has been stationed

there, to oversee all the GS/PM activities under the CRSP. We are sure that the research results and improved crop hybrids and varieties being developed in these two countries will spread into Latin America from this bridgehead. This largely circumvents the politial problems which so hinder attempts to get improved varieties and practices to needy small farmers in that region.

Other areas:

In our last report we urged that special attention should be given to Latin America, because the pest and disease situation is similar to that in the U.S.A. The region to the north of the Equator, and much germplasm and expertise is thus immediately applicable. We consider that our suggestion has been well adopted, and we would not press for additional efforts to the south.

We fully approve of the steps which have been taken in the much more difficult task of getting effective work going in Africa. Reference has already been made in paragraph 10 above to these activities. We wish the staff of the universities operating under this CRSP God's help in their endeavors.

We trust that ways will be found to surmount the obstacles restricting activities in India.

STRIGA (WITCHWEED):

During the sessions, our attention was drawn to the very serious damage caused by this parasitic weed over extensive areas of Africa, also in India. We know this to be the major problem for the small GS/PM grower in Africa, requiring sustained research by a team of scientists embracing the disciplines of plant breeding, agronomy, plant pathology and plant physiology/biochemistry. The unique skills available in the U.S. Universities could make a big contribution towards solving [illegible] serious problem, but the cost would be far beyond the resources of this CRSP. [illegible]ould therefore urge the Board and the Director to seek ways of cooperating with other USAID schemes, with ICRISAT, and perhaps also with other donor agencies, in order to mount the sustained research effort required to control this parasitic plant. Thousands of acres go out of cultivation every year solely due to the presence of this damaging parasite which persists for decades, once it has encroached on the land.

INTERNATIONAL CENTERS:

We are encouraged to find how much interaction has developed with international centers, especially with ICRISAT. We would urge increased cooperation, and joint planning sessions occasionally, so that the maxiumum of complementary activity may be attained, without duplication of effort.

SOCIO-ECONOMIC STUDIES

The panel notes with pleasure that intentions to develop a socio-economic component expressed at the previous review are becoming a reality. This will result in a positive interactive contribution to the INTSORMIL program.

Social scientists can play several roles; these include baseline studies at the initial stage of project preparation; marketing studies to determine what must be done to promote economic incentives; production-economics studies; policy

studies; and broad analyses to project demand and supply. Socio-economic studies are often location-specific.

THE PROJECTS:

Project UK-2, Sudan: This project, to be completed in six to nine months, should provide useful information from which subsequent INTSORMIL initiatives should benefit. During the final stages of analysis of the socio-economic data, we encourage the biological scientists to familarize themselves with the study, raising questions where necessary to ensure that they can make their subsequent programs more relevant. The review of research policy should likewise provide useful information to help understand the institutional environment within which the scientists must act. This appears to be a strong project.

Project UK-1, Honduras: An initial survey has been completed in this project. Staff are strong professionally, Spanish speaking, have previous knowledge of the area, and have developed interactions with INTSORMIL biological scientists and nutritionists working in Honduras. This promises to be a strong project.

Project MSU-3, Honduras: Initial analysis of data has been completed in a region very close to UK-1. We recommend that results which promise to be interesting be written up and reviewed by the Honduras committee.

Project PBF-1, West Africa: We recommend that a synthesis of available socio-economic information relating to agriculture in the Sahelian countries be prepared. Review of the information could provide a basis for INTSORMIL to determine whether it has adequate data on which to plan and implement programs. If not, specific studies might then be suggested for project funding. Cataloguing of the studies and publications collected thus far might provide a valuable information source of benefit in the Sahelian countries. Research on market development and price policy is of top priority. This project is to be directed by excellent professionals and carried out by graduate students who speak French or are otherwise knowledgeable on overseas conditions. This focus should be encouraged and hopefully extended to other geographic regions.

Project KSU-3, India: This project appears to be well conceived and will be carried out by a well-trained scientist who speaks the local language. However, the study stands alone due to problems in obtaining clearance for additional INTSORMIL activities in India. India has a strong group of social scientists and ICRISAT has an active village level survey program in the country. The results of the study are not likely to contribute significantly to general INTSORMIL objectives. We recommend that a time-table be established to permit collection of necessary data and that project financing be provided throughout the necessary period.

AGRONOMY

The committee feels that the projects so classified here have the opportunity to fill the void between scientific accomplishment in the LDC's and the farmer, better than any of the other categories.

Project UN-5: The value of this project as it related to Fe, Al, N, and P is significant with special implications for the acid "cerrado" type soils of South America where aluminum toxicity is severe. The screening methodology seems capable of replacing similar work such as that in MSU-2.

Project UN-6: Dr. Maranville plans to spend a year beginning in July, in the Philippines, working directly on mineral element efficiency improvement with emphasis on N uptake and use.

Project UN-4: This project under the leadership of Dr. Francis is already underway in Tanzania. The emphasis of genotype X environment interaction with regard to farming sytems has special implication to experiment station development and/or improvement.

Project UN-11: Although presently not funded, we see productive contributions from cropping systems research with sorghum-legume rotations. Because of the location interaction it seems imperative that the research be done on location in the particular LDC('s), and if this condition is met we would recommend funding.

Project MSU-1: This project on seed factors influencing stand establishment problems duplicates the work of Peacock at ICRISAT in India, has no formal linkages, and may be too technical for practical application. We suggest that the project be re-oriented in collaboration with Peacock so as to avoid duplication, or be dropped.

Project KSU-6: This effort on Millet stand establishment is essential but is relevant (as stated in the review of sixteen months ago) only to the situation in the LDC's. We still would emphasize that most of the research should be done in the LDC's.

PLANT PHYSIOLOGY

Whereas the committee strongly appreciates the strength of this group as regards basic research, we must express concern as to its applicability to on-going research in the LDC's. Therefore, we encourage as much direction as possible to be given to short-term and direct application of both basic and applied projects.

Project UN-2: The objectives of this project emphasizing temperature, yield, and water stress interactions are significant in much of the world in relation to sorghum and millet production. We do encourage as much application as possible be made in the LDC's plus the continuation of drought screening work at Garden City. Concern exists as to the validity of the gradient system, as it might interact with additional soil moisture availability and climatic conditions. Therefore, we would encourage multiple evaluation such as Yuma and Garden City to better classify materials with a necessary third test being in the LDC's. Perhaps the corn comparisons, interesting as they may be, could be confined to non-INTSORMIL funding.

Project UN-1: This water relations project is sound but could use international linkages which will require less sophistication and an ability to handle much larger numbers. Considering the level of expertise and basic oriented research perhaps more of this with other international centers would be a first step as well as cooperative efforts with the breeding activities.

Project UN-3: This project on grain fill is completed.

Project UN-8: This climatology effort can hopefully involve even more overseas linkages than the Philippines, Tanzania, and Colombia. We see value as an extension tool to better relate growth cycles of sorghum and millet to periods of favorable rainfall. The breeder also needs this guidance in developing appropriate maturity genotypes. This project should be made to relate to the similar but more extensive work done at ICRISAT.

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Project KSU-2: We are pleased to see millet being evaluated for canopy temperature and water use efficiency. Direct application as in UN-1 may need to go through international centers and in collaboration with breeders.

Project TAM-21: We place this project under physiology only as it related to the support Jordan can give the breeding project where drought resistance is evaluated under low elevation and relatively high humidity as opposed to Rosenow's efforts in a situation over 1000M altitude and in low humidity. The root, photosynthesis, and wax information coming from this portion of the program is generally both unique and worthwhile. We did not hear from Page Morgan.

Project AU-1: The Arizona team includes this physiology approach which involves both a screening service to the breeder as well as more basic studies on physiological traits of parents and hybrids. The uniqueness of the environment as well as the interaction with Voigt and Webster makes this a strong program for both U.S. training as well as international linkages, more of which should be encouraged.

PLANT BREEDING

Integration of drought, deficiency, and resistance work into the plant breeding activities is now much more complete, noticeably in the Texas programs. We consider this desirable at all centers.

Project UA-1: Work on drought resistance is extremely important for most of the LDC's growing sorghums and millets. This project should be encouraged to continue. However, it appears that more coordination is needed with the drought resistance breeding work at Texas, ICRISAT, and even the drought physiology work at Nebraska. Testing and evaluation of elite germplasm selected in this project at LDC sites where drought is a major problem should strenghten linkages with LDC's.

Project KSU-1: This is the only INTSORMIL project that is working on pearl millet breeding and as such it is important. The direct usefulness of germplasm developed at Kansas for most of the LDC's was questioned in the last review meeting. This question still remains. Developing a collaborative testing and evaluation site in an appropriate country in West Africa would strengthen this project. The germplasm expected to come out of this project should be useful for areas with short seasons. The work on heritability and gene action in pearl millet is not high priority for the immediate food production needs of the LDC's.

Project MSU-2A: This project appears to lack focus and is spread out too thinly to have significant impact in the LDC's. It is concerned with i.e., toxicity, sorghum midge, armyworm, grain mold, leaf disease etc. resistance breeding and also is concerned with inheritance of multiple sources of resistance. Since work on Al toxicity is being handled by several others in this CRSP, coordination and collaboration with the other projects in this effort appears necessary. In the other areas also, ICRISAT and other projects in this CRSP are involved a lot. It appears that more examination of these issues may help to narrow down and focus this project into areas of direct use to the LDC's. The work on armyworm may be of value to LDC's, and work on stem-borer at a location in an LDC in Africa would be of great value.

Project UN-7: Basic work on comparative sorghum breeding methodologies with emphasis on recurrent selection is very important. Therefore, this project should be encouraged to continue. However, the lack of sufficiency of a breeding method

for use in LDC's sites is of concern. Since the efficiency of a breeding method for use in LDC's should be viewing in terms of speeding the breeding progress, the inclusion of off-season work would appear useful. This may offer a good linkage opportunity for this project.

Project TAM-21: This is an excellent project and perhaps the best example of work most useful and applicable to the LDC's. The germplasm coming out of this project continues to be in high demand both in the LDC's and the U.S. The overseas linkages in this project ~~and~~ are generally good. Perhaps more vigorous effort in distributing lines and hybrids from this project to more LDC's may be useful.

Project TAM-22: The work on disease resistance breeding is properly oriented to the needs of the LDC's. The linkages with LDC's appear good. In the area of drought resistance breeding it appears necessary to have more coordination with ICRISAT, Arizona, and Nebraska, all of which are actively working on this extremely important problem of the LDC's in the SAT. Another area which needs close coordination with other projects is the work in Al toxicity.

Project TAM-23: Work on insect resistance breeding is very important for the LDC's. This project continues to develop germplasm of use to many countries in the SAT. Since stem borers are extremely important in most parts of Africa, shift of emphasis to stem borer resistance breeding would be most useful. In the area of breeding for N and P efficiency, closer coordination with others working on this problem (particularly Nebraska) would appear useful.

UTILIZATION AND NUTRITION PROJECTS

Only one of the six projects in this section is on millet. One project deals mainly with project development and utilization, three involve biological evaluation for protein quality and digestibility, and the effects of anti-nutritional factors on utilization. Two of the projects are more concerned with consumption. The projects all have overseas linkages through direct control or through students.

More detail on home preparation methods for both cereals would be desirable. The effects of alkaline cooking (lime or ash) and of fermentation processes on chemical composition, functional properties, and nutritive value need study. The work on tannins is particularly welcome. The nutrients other than protein and calories should not be forgotten.

More nutritional quality evaluations are needed, especially on millet.

Project TAM-26: This is a good project, providing valuable information on utilization of sorghum as food, alone or in combination with other foods. The information is of value in developing countries and more efforts should be made to implement the various technologies developed. The research should be continued to elucidate problems related to processing functional and organoleptic quality. More work or similar work should be done on millet. The information should be made available to investigators in agronomy physiology and breeding, as well as to those concerned with socio-economic problems.

Project KSU-5: The objectives of this project are similar to others in this area and the research has been concerned mainly with millet. It was surprising to see studies on nutritive quality using guinea-pigs, animals not conventional for this type of work. Cholesterol is not a problem in the developing world. This was

the only project of the group with millet, so more conventional methodologies should be used to evaluate this grain.

Project PRF-3: This represents a project well carried out providing useful information on the nutritional problems in sorghum and the effects of processing on nutritive value. It is important to learn of the favors responsible for the low digestibility of protein and low energy availability.

Project PRF-4: Tannin content represents one of the main limiting factors in sorghum. Therefore, the work carried out under this project is very important, in utilization and in the effects on nutritive value.

Project MSU-3: The research done under this project is basic to projects on production and utilization. It was carried out well, obtaining useful information. More details are needed on preparation and consumption. Sorghum samples should have been obtained for evaluation. It was surprising that there was no mention of other groups of INTSORMIL also engaged in Honduras.

Project FAM-1: We felt that circumstances had hindered the operation of the project, since there was so little to report. We believe that the Director should inquire into the nature of these hindrances, and determine the prospects of this project being carried out effectively.

PLANT PATHOLOGY

Project TAM-24: This project continues to exhibit the model characteristics of an INTSORMIL project. Reviews of the two of the four sub-projects were presented, with an over view of the third one. Services to and consultations with developing countries, the development of educational information, the establishment of a network of international disease nurseries, the holding of conferences and workshops, training and education of a large number of students on campus and the development of a number of overseas linkages are significant achievements and areas of involvement. The development, storage and upcoming announcement newsletter of availability of antisera of eight sorghum viruses will be quite useful for easy, risk free identification. The development of multiple disease resistant, food cultivars in cooperation with breeding projects are applicable to developing nations. Collateral to this is the establishment of and transmission to LDC's of disease testing procedures. The panel recommends continued major support for TAM-24.

Project MSU-2b: The panel also recommends continued support for this project. Normal progress appears to have been made. The warm, humid condition of the location is similar to conditions in many of the developing countries. This is the only project dealing with sweet sorghums (sorgos) and nematode problems. The disease work with food grain types, study of grain molds and weathering, the development of several overseas linkages and the domestic trainees and education program for foreign students is noted with satisfaction.

Project PRF-2: This project has been totally revamped to emphasize now anthracnose of sorghum. The panel would agree that this project has merit provided strong cooperation is established with breeding projects, particularly PRF-3, in addition to the stated objectives, and overseas linkage can be established in addition to Egypt.

Project UN-10: This project is new and is primarily directed to sorghum virus diseases. Questions arise about its importance and relevance, since a strong, well established program (TAM-24) exists in Texas which has established overseas linkages and integration with other disciplines. We urge the INTSORMIL director to provide guidance to the leader of UN-10 to help establish a meaningful program which would include cooperation with breeding projects and collaboration with TAM-24.

ENTOMOLOGY

Project TAM-25: This project is the main field entomology project of INTSORMIL. Like TAM-24 is pathology, it is a model example of how a project should function and shares most of the characteristics of overseas linkages, training, conferences and workshops, consultancy services, supply of pertinent information and interdisciplinary research work. The panel is pleased with the established linkage with ICRISAT and would encourage continued close cooperation. Between the two centers, the important insect pests of the world can be dealt with in an orderly manner. The panel recommends continued support at about the same level be given to TAM-25.

Project MSU-2b: The panel has reservations about continued support at the present level to this project. The relative of various sorghum cultivars to midge infestation was reported (Tam-25) to be the same throughout the world. Therefore, project TAM-25 would appear to involve sufficient expenditure and effort for research on midge. Work with fall armyworm seems to be warranted under MSU-2b since moderate resistance to armyworm attack is reported in sorghum. The panel recommends that the midge work within MSU-2b be discontinued and that TAM-25 take full responsibility for midge.

Project KSU-4: This project is the only INTSORMIL project dealing with the storage and preservation of pearl millet grain. The subject is of importance to the LDC's. The panel recommends its continuance although perhaps at a lower level of funding since a great deal of the descriptive work has already been done. We would urge research with fumigants, as the practice is deployed on farmsteads in several developing countries. A more imaginative approach to the solution of the problems would be desirable.

SUMMARY OF PROJECT ASSESSMENTS

A majority of the projects were relevant and good. Some would benefit from better integration into the program.

Project KSU-1 does need a site in the developing world: and the heritability gene action studies do not seem relevant to the LDC's.

Project MSU-2 is wide-ranging: it should concentrate on a single problem.

Project FAM-1 has made but little progress.

Project MSU-1 needs to be redesigned to complement the ICRISAT work.

RECOMMENDATIONS

A system to allow for limited funding outside the present projects at participating or home participating universities which would be administered by the

director would be helpful.

The review committee members need to be updated on any changes in funding, projects, staff involvement, etc...

Submitted by,

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Ralph Cummings, Jr.
Hugh Doggett
Brhane Gebrekidan
Bruce Maunder
Bobby Renfro

Attachment B

SUMMARY OF ACTIONS TAKEN BY INTSORMIL
IN RESPONSE TO EXTERNAL EVALUATION,
FEBRUARY 1-5, 1982

The following actions were recommended by the Technical Committee of INTSORMIL, concurred in by the Program Director, and approved by the Board of Directors. All are being implemented as appropriate; special features or considerations are indicated.

1. Arizona.

No immediate changes were recommended, but Arizona was instructed to develop better direct overseas linkages during the coming year ("Year 4").

2. Florida A&M.

Zero funding for Year 4. The institution was retained in the CRSP structure, but informed that it must show progress in implementing proposed activities before further funding can be granted.

3. Kansas State University.

As a general consideration, $60,000 of proposed Year 4 sub-grant funds were withheld until KSU can demonstrate specific action on arranging staffing for overseas activities. Project actions were:

KSU-1. Financial support for heritability studies was terminated and these studies were dropped from the project.

KSU-3. Notice was given to terminate field studies by November 1982. The project will be closed by June 1983.

KSU-4. The proposed budget was reduced, and the project leaders were cautioned to become more closely involved with other INTSORMIL activities. This resulted in immediate action to tie the project research much more closely with ongoing INTSORMIL programs in Sudan.

KSU-5. The proposed budget was reduced, work on ascorbic acid was dropped, and the project assumed more direct ties with planned work in India.

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KSU-6. Closer contact with related work at ICRISAT was mandated and has been undertaken. The project was instructed to make every effort to place a staff member overseas; this has not yet been implemented but appropriate planning is underway. It appears that a full-time agronomist will be stationed in Botswana.

4. University of Kentucky.

The excellence of the field work being conducted was recognized, and significant budget increases for field work in Year 4 were effected.

5. Mississippi State University.

MSU-1. The project was continued at a lower funding level than previously authorized. Project workers were instructed to pay special attention to coordination with similar ICRISAT work.

MSU-2. This project, considered by the External Panel to be too broad in scope and lacking focus, was completely restructured in new projects MSU-4,5 and 6, as indicated below.

MSU-3. Project to continue as planned, with sociology component terminating in Year 4. Efforts are to be made to involve nutritional aspects of study with related field work in India.

MSU-4 (breeding). Main focus to be on selection for tolerance to acid soils, aluminum toxicity and phosphorous stress. Goals of high grain quality and resistance to head molds and fall army worm will be continued. Major field work in South America (CIAT) will begin in 1982.

MSU-5 (entomology). Work on sorghum midge is being dropped. Emphasis on fall army worm will be retained and efforts on stem borers will be increased.

MSU-6 (pathology). Effective program now being conducted at Meridian will be moved to Starkeville and continued.

MSU-11. A field program at CIAT was authorized.

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6. University of Nebraska.

A major reorganization of projects in agronomy was carried out, reducing the number of projects from 7 to 4. A new project in plant pathology, approved on a temporary basis for Year 3, was given continuing authorization for Year 4. The project leader of the former NE-6 project will conduct his major research in the Philippines, cooperating with IRRI and the University of the Philippines, for the entire Year 4.

A full-time, internationally-oriented academic staff member is to be added to the Department of Agronomy late in 1982.

7. Purdue University.

PRF-1. Funding was reduced by 60% for Year 4 and the project will be terminated at the end of Year 4.

PRF-2. The project was terminated; some aspects of the work are being continued as a new project, PRF-6.

PRF-3. No changes recommended, but a new, full-time staff member will be added in Year 4.

PRF-5. Approved for regular funding with a major overseas component

8. Texas A&M University.

No significant changes recommended, since 1981 reorganization has proved highly effective.

9. Management Entity.

Addition of half-time Assistant Director and modest budgetary increase approved.

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INTSORMIL EXTERNAL REVIEW
February 1-5, 1982

SCHEDULE OF EVENTS

SUNDAY, JANUARY 31, 1982:

8:00 P.M. - ± Meeting of External Panel with Program Director and Board Members - Kansas Room

MONDAY, FEBRUARY 1, 1982: Ballroom

8:30 A.M.	-	Opening Session	- Floyd Smith
9:00	-	Linkage overview	- Earl R. Leng
9:20	-	Honduras	- George Teetes, Dan Meckenstock
9:50	-	Mexico/CIMMYT	- Fred Miller, Lloyd Rooney
10:10	-	Coffee break	
10:30	-	CIAT/South America	- Richard Frederiksen
10:50	-	India	- Earl R. Leng, Barry Michie
11:20	-	ICRISAT	- John Axtell, et al.
		LUNCH BREAK	
1:15 PM	-	Philippines/IRRI	- Charles Francis
1:30	-	Mali	- Art Onken
1:50	-	Sudan	- Richard Frederiksen, Allen Kirleis
2:20	-	Egypt	- Jerry Eastin
2:40	-	Niger	- John ~~Axtell~~ Clark
3:00	-	Coffee break	(Tues. p.m.)
3:25	-	Botswana	- Glen Vollmar
4:00	-	Others	- Earl Leng
4:30	-	FAO	- Earl Leng

10 minutes

7:30 Tech Comm Mtg
Kansas Room

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TUESDAY, FEBRUARY 2, 1982 - Ballroom

Socioeconomics - Billie DeWalt, Chairman

8:30 A.M.	-	Opening remarks	
8:45	-	KSU 3	- Barry Michie
9:00	-	MSU 3	- Eunice McCulloch
9:15	-	PRF 1	- Bill Morris
9:30	-	UK 2 (Sudan)	- Billie DeWalt
9:45	-	UK 1 (Honduras)	- Kathleen DeWalt
10:15	-	Coffee break	

Utilization-Nutrition - Allen Kirleis, Chairman

10:35	-	TAM 26	- Lloyd Rooney
10:50	-	KSU 5	- Carl Hoseney
11:05	-	PRF 3	- Allen Kirleis, John Axtell
11:25	-	PRF 4	- Larry Butler
11:40	-	MSU 3	- Mary Futrell
11:55	-	FAM 1	- Hetty Banatte
		LUNCH BREAK	

Pathology - Richard Frederiksen, Chairman

1:15 P.M.	-	General Topics	- Richard Frederiksen
1:45	-	PRF 2	- Herman Warren
2:00	-	MSU 2 (part)	- Natale Zummo
2:15	-	UN 10	- Stan Jensen
2:30	-	TAM 24	- ~~George~~ Toler, Gary Odvody
2:50	-	Striga research needs	- Richard Frederiksen
3:00	-	Coffee break	

Entomology - George Teetes, Chairman

3:20	-	General remarks	- George Teetes
3:30	-	KSU 4	- Robert Mills
3:50	-	MSU 2 (part)	- Henry Pitre
4:10	-	TAM 25	- Frank Gilstrap, George Teetes

7:00 Sudan - Kansas Room

WEDNESDAY, FEBRUARY 3, 1982 - Ballroom

Agronomy - Richard Vanderlip, Chairman

8:30 A.M.	-	Opening Session	- George Teetes
8:45	-	UN 5	- Ralph Clark
8:55	-	UN 6	- Jerry Maranville
~~9:05~~	~~-~~	~~TAM 23~~	~~- Art Onken~~
9:15	-	UN 4	- Charles Francis
9:25	-	UN 11	- Max Clegg
9:30	-	MSU 1 -	- James Delouche
9:40	-	KSU 6	- Richard Vanderlip
9:50	-	Summary of Agronomy Projects	
9:55	-	Coffee break	

Physiology - Al Dobrenz, Chairman

10:15	-	UN 2	- Jerry Eastin
10:25	-	UN 1	- Charles Sullivan
10:35	-	UN 3	- Charles Francis
10:45	-	UN 8	- Ralph Nield
10:55	-	KSU 2	- Ed Kanemasu
~~11:05~~	~~-~~	~~TAM 21~~	~~- Page Morgan~~
11:15	-	TAM 21	- Wayne Jordan
11:25	-	~~AU 1~~ UA	- Al Dobrenz
11:35	-	Summary of Physiology Projects	
		LUNCH BREAK	
1:15	-	Introduction, Plant Breeding	- Darrell Rosenow
1:25	-	UA 1	- Robert Voigt, Victoria Marcarian
1:40	-	KSU 1	- Bill Stegmeier, Frank Barnett
2:10	-	MSU 2	- Lynn Gourley
2:35	-	UN 7	- Bill Ross
2:55	-	Coffee break	
3:15	-	TAM 21	- Fred Miller
3:40	-	TAM 22	- Darrell Rosenow
4:05	-	TAM 23	- Darrell Rosenow, Art Onken
4:30	-	General Discussion	
4:45	-	Wrap-up session	- Earl Leng
Evening	-	Technical Committee Meeting (tentative)	

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THURSDAY, FEBRUARY 4, 1982: Parlor Rooms (schedule to be announced)

8:30 A.M.	-	Discipline groups - planning session
		Agronomy -
		Physiology -
		Breeding -
		Socioeconomic -
		Utilization/Nutrition -
		Pathology -
		Entomology -
10:00	-	Coffee will be available
12:00	-	LUNCH BREAK
1:30	-	Continuation of discipline groups or individual country-program meetings
3:00	-	Coffee break

FRIDAY, FEBRUARY 5, 1982 - Ballroom

9:00 A.M.	-	General session - Panel report - Hugh Doggett.
10:00	-	Meeting of EE Panel with Board of Directors. Room to be announced.

NOTE: A special nutrition workshop will convene at 8:30 A.M. - place and program to be announced by John Axtell.

INTSORMIL EXTERNAL EVALUATION
February 1-5, 1982
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INTSORMIL AUTHORIZED PROJECTS
as of January 1, 1982

INSTITUTION	PROJECT NO.	SHORT TITLE
U. Arizona	XII UA 1	Sorghum Selection for Arid Conditions
Florida A&M	XII FAM 1	Sorghum Food Utilization
Kansas St. U.	XII KSU 1	Pearl Millet Breeding
	2	Physiological and Developmental Processes
	3	Farming Systems Studies in India
	4	Storage and Preservation of Pearl Millet
	5	Nutritional Quality of Pearl Millet
	6	Seedling Vigor and Stand of Millet
U. Kentucky	XII UK 1	Sociological Constraints on Sorghum and Millet Productior
	2	Field Studies in Sudan
Mississippi State U	XII MSU 1	Seed Factors, Strands and Emergence
	2	Sorghum Crop Protection/Pest Management
	3	Human Nutritional Improvement
U. Nebraska	XII UN 1	Sorghum Drought Resistance
	2	Temperature Stress in Sorghum and Millet
	4	Adaptation and Yield Stability
	5	Sorghum/Millet Mineral Efficiency
	6	Nitrogen Uptake in Sorghum and Millet
	7	Sorghum Recurrent Selection
	8	Climatology of Grain Sorghum
	10	Sorghum Virus and Stalk Rot Diseases
	11	Sorghum Cropping Systems
Purdue Research Foundation	XII PRF 1	Socio-Economic Constraints
	2	Mechanisms of Sorghum Disease Resistance
	3	Development of Superior Grain Sorghums
	4	Enhancement of High Tannin Utilization
	5	Pricing and Trade of Sorghum and Millet
Texas A&M University	XII TAM 21	Breeding Sorghum for Productivity
	22	Breeding for Disease and Drought Resistance
	23	Breeding for Insect Resistance and Nutrient Efficiency
	24	Sorghum and Millet Pathology
	25	Sorghum and Millet Entomology
	26	Food Use, Quality and Nutrition
	31	Honduras Sorghum Development

INTSORMIL - ANNUAL REPORT NO. 3

THE UNIVERSITY OF ARIZONA

Project Name: Evaluation and Development of Sorghum/Millet Germplasm for Arid Land Agriculture

Project Number: XII UA 1

Personnel: a. Investigators: V. Marcarian, A. K. Dobrenz, R. L. Voigt, O. J. Webster

b. Graduate Students:
A. Agbary - Yemen
P. Bimpolo - Congo
P. Bourque - U.S.A.
S. Boye-Goni - Ghana
C. Chigwe - Malawi
W. Hoffman - U.S.A.
M. O'Neil - U.S.A.
A. Tubaileh - Jordan

Overseas Linkages:

Mexico - R. L. Voigt submitted 100 sorghum entries to ICRISAT for evaluation.

Mexico - CIMMYT-ICRISAT - Screened 69 entries in Sprinkler Irrigation Gradient.

Senegal - ISRA (Bambey, Senegal) - M. M'bodj visited Yuma, made sorghum and millet selections.

Mali - M. O'Neil trained nationals to use neutron probe and explored possibility of establishing gradient for ICRISAT.

Mali - O. J. Webster reviewed ICRISAT Sorghum/Millet Program

Zambia - O. J. Webster advised local government as to research to be initiated to improve sorghum/millet production.

India - O. J. Webster attended "Sorghum for the 80's" conference.

Major Objectives:

1. Identify drouth tolerant grain sorghum/millet genotypes through use of irrigation gradients in an arid climate.

2. Increase drouth tolerance levels through controlled crossing, selection and recurrent selection, under low moisture and high temperature.

3. Study physiological and morphological attributes of sorghum types which can tolerate low available soil moisture.

4. Evaluate sorghum/millet lines for other desirable agronomic characters.

Major Objectives (Continued):

5. Develop a graduate student training program for U.S. and international students interested in pursuing careers in developing countries.

6. Develop international linkages for collaborative research in sorghum/millet improvement in arid and semi-arid regions.

7. Determine socio-economic impact of increased agricultural productivity.

Significant Recent Findings:

1. Nine sorghum genotypes determined to be drought tolerant and 9 genotypes determined to be drought susceptible in the Yuma irrigation gradient had a significant positive correlation for grain yield in a field test under similar stress conditions.

2. A replicated field grain yield test under moisture stress showed 23 of 340 (7%) line selections from one heat and moisture stress acclimated population and 15 of 139 (11%) line selections from another similarly treated population to be statistically equal to or superior to hybrid RS626 in grain yield under heat and moisture stress.

3. Twenty-six and 37 different entries respectively, from the two populations above were evaluated under the irrigation gradient at Yuma where about one-third of each group appeared to produce heads and stay alive under very severe drought and heat.

4. A sprinkler irrigation gradient system to apply high, medium, low and zero levels of irrigation was established at the University of Arizona Experimental Farm, Yuma, AZ. Three hundred and sixty-seven sorghum/millet lines obtained from collaborating U.S. (Arizona, Nebraska, Texas A & M, Colorado, Kansas, DeKalb) and international (CIMMYT/ICRISAT) institutions were screened for drouth tolerance. Physiological and morphological data were also obtained. See 1981 Sorghum/Millet Title XII CRSP Research Report.

5. Research on drought tolerant and drought susceptible sorghum hybrias and their parents measured over a wide range of environmental conditions has been used to develop regression analysis which could be used by LDC's for prediction of superior sorghum/millet lines. Two years of data has been summarized on characteristics related to yield in arid environments.

6. Three cycles of selection for aluminum tolerant sorghum germplasms have been completed. Aluminum tolerant lines are available for field evaluation in problem soils of LDC's.

Project No.: XII FAM 1

Project Name: Identification of Cultural Food Habits and Utilization of Grain Sorghum/Pearl Millet for basic foods.

Personnel: Dr. Hetty Deane Banatte

Overseas Linkages: University of the West Indies
Jamaica, West Indies

Major Objectives:

1. Establish linkages with institutions and/or organizations in both the U.S. and the Caribbean area to facilitate research efforts on the project.

2. Design and pre-test an instrument for identification of food habits, beliefs and attitudes.

3. On a representative sample of the population execute a food-habit survey, and analyze the data.

4. Develop country research capacity and design and execute nonformal education programs to improve women's skills in the utilization with consequent nutrition information of the Sorghum/Millet.

Significant Recent Findings: Florida A&M University has defined the Caribbean and West Africa as the geographical focus of its interest in international development assistance programs. This is clearly outlined in its Title XII Strengthening Grant Proposal which was approved in June 1980.

Linkages have been developed with the University of the West Indies, Mona campus in Jamaica; (UWI) the Caribbean Food and Nutrition Institute, also in Jamaica; and with the CARICOM Secretariat in Georgetown Guyana. At a meeting of the Caribbean Association of Nutritionist and Dietitians, there was much discussion on the introduction of Sorghum/Millet into the entire Caribbean area. This discussion was followed up by meetings at UWI, when the production and utilization were the main topics discussed. As active plans are now being made to enter into projects with these organizations, it is hoped that Sorghum and Millet will take their place as a major project in the area.

A team visit (Dr. Futrell and Dr. Banatte) was made to Haiti in connection with the implementation of the Sorghum/Millet project. These technicians had meetings with several government officials who expressed their interest in the project.

A follow-up visit was made to Haiti by officials of the College of Science & Technology as part of the Governor of Florida's mission to Haiti.

It is understood that Texas A&M University has been awarded a contract from United States Agency for International Development in basic food crop production. Cereals, edible legumes, tuber crops and farming systems are receiving emphasis under this program.

It is expected that Florida A&M University will be able to complement Texas A&M University's basic food crop production by contributing expertise in and information on cultural food habits and utilization of these basic foods. This type of assistance will fit into the research package invisioned for involvement in Haiti by Florida A&M University.

PROJECT TITLE: Pearl Millet Improvement Program PROJECT No. XII KSU1

PERSONNEL: W. D. Stegmeier and T. L. Harvey, Fort Hays Experiment Station
F. L. Barnett and B. Khaleeg, Department of Agronomy

OVERSEAS LINKAGES: Formal linkages with LDC'a have not been established at this time. Exchanges of materials are taking place with ICRISAT personnel and arrangements of exchanges have been initiated with workers in Senegal, Mali, and Niger.

MAJOR OBJECTIVES:

1. To develop widely adapted pearl millet germ plasm, with special emphasis on early maturity, improved seed size, seed set, and agronomic characteristics, and high nutritional quality.
2. To study the inheritance of major grain quality characteristics, high establishment capacity, insect resistance, and agronomic characteristics.
3. To evaluate materials developed in this program under a wide range of environments, including those of developing countires.

SIGNIFICANT RECENT FINDINGS:

1. Development of pearl millet materials adapted to a wide range of latitudes continued with the evaluation and advancement of 9 populations in recurrent and mass-selection regimes, 3000 inbred lines, and over 500 F_1 hybrids. F_2 families derived from crosses of P-924B (an early maturing variety from northern Niger) and 3 Kansas inbred lines produced segregates that matured seed at Carrington, North Dakota (47° N Lat.) and at Brandon, Manitoba (50° N Lat.). Population FR-RM(3) half-sib families grown at Meade and Sydney, Nebraska produced S_1 selections suitable for Nebraska. Crude protein level appears to remain high with increasing grain yield levels.

2. Tests have been established to identify lines having superior combining ability for crude protein content, grain yield, seed weight, and lodging resistance.

Seedling tolerance to the phytotoxin produced during biotype E greenbug aphid feeding was determined on 120 ICRISAT lines, 31 Yemen lines and several hundred Kansas lines with tolerance levels appearing to be reduced compared to previous tests involving biotype C phytotoxicity. The inheritance of reaction to the greenbug is being studied. Preliminary evaluation of height modifying genes within the D_2 height range (60-150 cm) indicate the presence of at least two modifiers.

A Ph.D. study (M. Lawan, Nigeria), investigating the basis for seed density differences in pearl millet is nearing completion. Field studies indicate that population and seed density are major factors affecting germination, emergence, vigor, days to anthesis, and grain yield. Density and size interacted in their effects on field emergence and days to anthesis with density having more impact at the lower range of seed size and vice versa. Density and population interacted in their effects on germination. Laboratory results indicate a positive relationship between density and proportion of kernels with vitreous endosperm, and a negative relationship between density and relative size of embryo (germ face). Relationships among seed protein content, density, and size are complex and appear to vary from population to population.

A heritability-and-gene-action study (Comstock and Robinson Model 1) on seed and head characteristics of pearl millet was initiated in 1981. Families derived from crossed, selfed, and open-pollinated heads will be planted in 1982.

Mass selection with six isolations of two populations [HMP 550 and RMP 1(S) C1], for high, medium and low seed weight (Core Study, 1980) produced approximately 6000 selections. Selection for high, medium, and low seed weight will be continued in the next generation.

3. Gradient drought stress screening of 50 items at Yuma, Arizona identified two inbred lines and 3 F_1 hybrids possessing good drought tolerance. Lines and populations screened for storage insect activity indicate the existence of differences in levels of insect damage. Hybrid varieties were evaluated in Arizona, Texas, Kansas, Nebraska, and Indiana with varying levels of success noted. Seeds of 50 and 54 items were sent to ICRISAT workers in India and Sudan and 9 items to Mauratania. Verbal reports received to this date indicate satisfactory growth and development has occurred in India.

INTSORMIL Review

February 1982
Kansas City

Project Name: Physiological and Development Processes-Project No. XII KSU 2
Edward T. Kanemasu and Utsab Chaudhuri
Kansas State University

Overseas Linkages: Cooperative arrangements have been made with Haryana Agricultural University and ICRISAT to determine the potential of canopy temperatures as a selection technique in assessing drought resistance. Dr. Phool Singh from HAU has spent 6 months at Kansas State University (January to July 1980). Upon returning to HAU, he has developed a cooperative field experiment with ICRISAT (Dr. Seetharama). In September 1981, I visited with Drs. Singh and Seetharama at ICRISAT and reviewed the project. I am corresponding with Dr. Sinha at the Water Technology Centre in New Delhi about a cooperative project. Dr. Piara Singh has completed his Ph.D requirements at KSU and has rejoined ICRISAT.

Major Objectives

I. Comparisons of the effect of water on sorghum and millet growth, yield components, water use efficiency, and water use - Manhattan (cooperation with Nebraska)

II. Assessing canopy structure properties from spectral data - Manhattan

III. Use of canopy temperatures in assessing drought resistance of millet genotypes - Hissar, India (cooperation with Haryana Agricultural University and ICRISAT)

IV. Use of canopy temperatures in assessing drought resistance of sorghum genotypes - Hyderabad, India (cooperation with ICRISAT)

Significant recent findings

Statistically significant differences among millet genotypes were observed in various physiological responses, but the differences among genotypes in leaf diffusion resistance, canopy temperature, and canopy minus air temperature were relatively more significant and consistent. In both irrigated and nonirrigated environment, grain yield was negatively and significantly correlated across genotypes with their cumulative canopy temperature (SUMCT), cumulative canopy minus air temperature (SUMCT-AT), and cumulative leaf diffusion resistance (SUMLDR). Grain yield ratio (nonirrigated grain yield/irrigated grain yield was negatively and significantly correlated across genotypes with SUMCT, SUMCT-AT, and SUMLDR and SUMCT-AT in the irrigated treatment. These results indicate that when selecting for high yields and yield stability under well watered conditions, genotypes should have high SUMLDR or SUMCT; but when the selection is done under a water-stressed environment, genotypes should have low SUMLDR or SUMCT or SUMCT-AT.

Spectral measurements indicate that both dry weight and leaf area index are highly correlated with reflectance in the red and near infrared wavelengths. Previous studies have reported that intercepted radiation which is a function of incoming solar radiation and leaf area index, is strongly correlated with yield. A spectral radiometer could serve as a rapid screening device in a breeding program.

SUMMARY OF WORK

PROJECT: A Farming Systems Approach to Millet Production XII KSU-3

PERSONNEL: B. Michie (PI), Janet Benson, David Norman

OVERSEAS LINKAGES: Project is formally affiliated with the University of Udaipur, Rajasthan, India, with administration through the American Institute of Indian Studies, New Delhi. Field work is being conducted in nine villages in Sikar District, Rajasthan, in coordination with the university branch campus at Jobner and branch stations at Durgapura and Jotwara that are close to the field sites. Informal links are with ICRISAT, Hyderabad, particularly with the Economics Program.

MAJOR OBJECTIVES: 1) Augment Univeristy of Udaipur's research programs, 2) further develop farming systems analysis and application, linking technical and social science dimensions, 3) develop/modify technologies and strategies for millet production, 4) improve well-being of small and marginal farmers, 5) develop tried and tested technologies for wider extension.

SIGNIFICANT RECENT FINDINGS: So far no findings since project administrative arrangements were finalized only in early November and funds made available for use in India only in middle December. A project coordinator has been hired who has extensive experience in managing rural development and village level programs in Rajasthan.

The last two weeks of December were spent in extensive touring of Sikar District to obtain a first hand familiarization with the district, meet district officials, talk with farmers, and visit potential village sites. Visits were also paid to university research and extension centers in Sikar and adjoining Jaipur Districts.

Sikar affords a wide range of agro-climatic conditions: entisol and inceptisol soil categories, a rainfall gradient from 350 to 750 mm, completely rainfed single crop to irrigated double crop regimes, and millet grown as the main crop under all conditions during the Kharif monsoon season (July - September/October).

Specific problems identified for technical work are: salinity and drought stress; irrigation and water conservation; striga, ergot, white grub, hairy caterpillar. The branch campus at Jobner has major funding for work in salinity and drought stress research - mainly in millet breeding - and also for white grub. It also has been doing work on ergot.

The response of people at the university centers has been extremely encouraging. They have been working on problems on-station and feel the need for closer ties to the farm level that so far have been ad hoc. They are most anxious for making use of the project field sites for testing and modifying what they have developed so far, particularly given the long term monitoring and interaction with participant farmers afforded by the project. This point should be emphasized that at all levels - district officials, university main campus and regional centers and branches - there has been exceptional support and interest in seeing the project off the ground.

In the next few months the project will have resident investigators in selected village sites. Data collection will be well underway before the upcoming millet season beginning in July when technical dimensions can begin to be tested.

Project Name: Storage and Preservation of Pearl Millet Project No.: KSU-4

Personnel: Robert B. Mills, Co-Investigator, Department of Entomology, KSU
John R. Pedersen, Co-Investigator, Department of Grain Science and Industry, KSU

Overseas Linkages:

Dr. Dansou Kossou, Fac. of Agric. Sc., Nat'l Univ. of Benin, Cotonou, R.P. Benin.

Mr. Frank Bolduc, P.N.U.D., D.P. 120, Bamako, Mali.

Mr. A.J.D. Barker, FAO Storage Specialist, Office Cerealier, B.P. 298, Garoua, Cameroon.

Mr. Lazare Iloga, (Mr. Barker's Cameroon counterpart).

Member Institutions of GASGA and their representatives.

Major Objectives:

1. Determine the extent of insect and mold problems in stored millet in LDC"s
2. Determine the species and relative abundance of stored-grain insects and molds, and determine which are most damaging to pearl millet in LDC's.
3. Evaluate storage facilities and techniques, and develop improvements where appropriate.
4. Evaluate local storage-insect control methods for effectiveness, and develop improvements where appropriate for LDC's.
5. Conduct laboratory research at KSU on resistance of pearl millets to insect species that are problems in LDC storage, and on biology and behavior of those species.
6. Evaluate relationships between damage done by threshing and handling, and insect and mold problems.
7. Training of LDC personnel will be an important aspect of the project, and will be done both in LDC's (if arrangements can be made) and at KSU, by short courses demonstrations, or formal graduate study at KSU.

Significant Recent Findings:

1. In screening entries of millet for resistance to rice weevils (*Sitophilus oryzae*), the average number of weevil progeny ranged from 10.3 to 125.7 per sample; mean, 59.1. Small-seeded lines were generally more resistant.
2. No consistent location differences were found in resistance to rice weevils or Angoumois grain moths (*Sitotroga cerealella*) of 27 lines (mostly hybrids) grown in 2 locations in Kansas.
   More rice weevils were produced in threshed grain than in heads; Angoumois grain moths exhibited no differences.
3. The rice moth (*Corcyra cephalonica*), a common millet pest in Africa, had a higher rate of larval survival and shorter developmental periods in millet than in rice, corn, sorghum, or wheat.
4. Size of Angoumois grain moths was influenced by size of kernels in which they developed: small millet, 3.61 mm; large millet, 4.67 mm; sorghum, 4.76 mm; corn, 5.37 mm. Dry wt. loss/kernel caused by single Angoumois grain moths ranged from 4.66 mg in small millet to 25.2 mg in corn.
5. An oil distillation moisture method for millet worked equally well with prescribed or vegetable oil at 180°C, however, these measurements were generally lower than those by official air oven methods (whole kernel, 103°C/72 h; ground, 130°C/1 h). Effects of different times at 120°C (whole kernels) on moisture measurements for millet at 10,13, and 16% M.C. were determined.
6. In the absence of other deteriorative factors, internal insect infestation in millet can be determined by a simple germination test, in lieu of more complex methods (X-ray or cracking-flotation).
7. A layer of crushed millet "cobs" (without kernels) 15 cm deep prevented 85% of introduced rice weevils from reaching millet below for 14 days; 10 cm restricted 70%; 5 cm restricted 30%.
8. Eight villages from the northern to southern parts of Senegal were visited May 24 to June 7, 1981. Twenty-two storages were observed and sampled. Due to recent drouths, little millet was stored. The most common insects found were red flour beetles and rice moths. Little damage was observed in

Nutritional Quality of Pearl Millet - XII KSU-5

sonal:

. C. Hoseney, E. Varriano-Marston (position now open), Carol Klopfenstein, .. Simwemba, A. Abdelraham, Selma Adbul-Hussian, Kathy Zeleznak, I. Kaced, M. Olewnik, and Alicia de Fransico.

Overseas Linkages:

ICRISAT; Home Science College, Hyderabad, India; Food Research Center, Khartoum Sudan; and ITA, Dakar, Senegal.

Objectives:

1. Determine how pearl millet (and sorghum) are prepared and consumed in traditional foods.

2. Divise standardized laboratory procedures to prepare and test quality of traditional food products.

3. Evaluate and identify breeding lines of millet (and sorghum) with improved nutritional quality.

4. Determine chemical components and physical characteristics of pearl millet grain which may reduce digestibility or nutrient availability, or interfere with end-use food quality.

5. Develop fundamental knowledge of the properties of various quality-related chemical components of sorghum and millet grain.

Significant Recent Findings:

Guinea pigs fed grain sorghum diets had lower liver cholesterol concentrations than animals fed wheat, oats, or pearl millet. Grain sorghum diets supplemented with low levels of ascorbic acid produced poor growth and unhealthy animals. Supplementation with high levels of ascorbic acid produced optimum growth. In pearl millet phytic acid was lower than wheat and varied by line and location of growth. B-Vitamins varied widely in pearl millet, mostly as a result of location. Oxidative rancidity of pearl millet meal appear to be different than that found in wheat. A procedure has been developed for making pearl millet rotis. Alpha-amylase from germinated pearl millet was isolated and characterized. Hardness of pearl millet and grain sorghum cannot be estimated by visual appearance. A milling process was developed to produce low-fat pearl millet grits.

Project Name: Seedling Vigor and Stand Establishment of Pearl Millet

Project Number: XII KSU 6

Personnel: Richard L. Vanderlip, H. A. Praeger, Jr., Mithlesh Kumar, and Julius Okonkwo

Overseas linkages:

Collaborative work has been done with Dr. F. R. Bidinger and Dr. R. K. Maiti at ICRISAT (see below). Preliminary contacts have been made with Clive Lightfoot in Botswana regarding field testing under their conditions.

Major objectives:

1. Identify seed and seedling characteristics associated with field establishment performance of pearl millet.

2. Identify and evaluate germplasm with the capability of establishing normal stands under stress conditions particularly temperature, moisture, and high salt conditions.

Significant recent findings:

Mwageni (Tanzania) found that standard germination and a number of seedling vigor stress tests which had been used on sorghum did not correlate well with pearl millet field establishment. Gardner (USA) found that seed size and seed density were positively related to stand establishment. Moreover, large or heavy seeds resulted not only in greater stands but also in greater yields. Based on these results Okonkwo (Nigeria) applied several management treatments, tiller removal, head shaving, late nitrogen application, and hill planting, to millet in an attempt to change the physical characteristics of the seed. Results from one year indicate that the management treatment significantly affected seed size, seed density, and seed protein content. However, the effects on seed density were minimal and in general did not increase seed density. Seed from two of the treatments, head shaving and late nitrogen application, resulted in significantly higher field emergence and those from the head shaving treatment resulted in significantly higher grain yields.

Another problem with field establishment is the problem of planting with the first rains and then erratic rainfall resulting in severe moisture stress on the seedlings. Kumar (India) working both in Kansas and at ICRISAT compared several moisture stress techniques with field plantings in an attempt to identify genotypes which had the capability to withstand early seedling moisture stress. Screening techniques using limited moisture and increased osmotic stress from polyethylene glycol were utilized. Correlations with field results were significant but not exceptionally high.

Project No.: XII UK 1

Project Name: Sociocultural Constraints in the Production and Consumption of GS/PM in L.D.C.'s

Personnel:

C. M. Coughenour, L. Busch, B. DeWalt, K. DeWalt, B. Lacy

Overseas linkages:
1. Sudan: Agricultural Research Corporation, and the Faculty of Agriculture, University of Khartoum;
2. Honduras: Ministry de Recursos Naturales, and the Instituto Hondureno de Anthropologia e Historia;
3. India: ICRISAT.

Major objectives:
1. Description of (1) farming strategies in raising sorghum/millet, (2) the distribution of the grain produced, (3) the types, quantities, and qualities of sorghum/millet consumed and (4) the identification of constraints to increased production and consumption.
2. Identify: (1) barriers to effective communication among scientists, (2) barriers to appropriate and effective research, (3) appropriateness of research products to farmers' needs, (4) ways of reducing communication barriers, (5) faulty assumptions about farming systems made by researchers, and (6) a methodology for assessing appropriate technology.

Significant recent findings:
1. In the Sudan around el-Obeid, the preferred farming strategy of small farmers is to plant quick-maturing varieties of sesame and millet to obtain quick returns. Larger farmers initially plant longer maturing varieties which produce more heavily. Small farmers are constrained in use of the preferred strategy because (1) they do not possess the quick-maturing seeds of millet and sesame, nor can they afford to purchase them; (2) labor shortages, especially if replanting is necessary due to drought; (3) lack of varietal resistance to simta bugs. A seed propagation and improvement program is needed.

2. In Honduras in the Pespire region, the strategy preferred by farmers is a slash-mulch-burn system of cultivation involving corn and sorghum. Sorghum is grown for grain and for fodder. A seed improvement and seed propagation system is needed. There is need (1) for improvement in quick growing, insect resistant, and high food quality varieties which exist; (2) varieties for human as well as animal consumption are needed; and, (3) for improved cultivation methods that minimize erosion.

3. At the Sorghum in the 80's symposium Busch and Lacy obtained data from more than 100 scientists as to their (1) current research, (2) research goals, (3) adequacy of support, and (4) access to sources of information and contacts with scientists. Data analysis is underway.

MISSISSIPPI STATE UNIVERSITY

Project Name: Seed Factors Influencing Germination, Emergence, and Stand Establishment

Project Number: XII/MSU-1 (390-1505/MIS-1505)

Personnel: J. C. Delouche, C. H. Andrews, H. C. Potts, G. Reusche, E. Cabrera

Overseas linkages: Formal overseas linkages have not yet been established. Informal relationships are in effect in several countries (e.g., Colombia/CIAT, Upper Volta, Botswana, Honduras) in connection with seed program advisory services (AID). Formal linkages will be organized in Spring, 1982, especially for Obj. 1.

Major Objectives (abbreviated):

1. Analysis of emergence and stand establishment problems in selected sorghum and millet production areas.
2. Characterization of sorghum and millet seed germination and emergence in terms of general responses to temperature, soil moisture tension, mechanical impedence, and salinity.
3. Identification and characterization of heritable characters of sorghum and millet seed associated with superior seed quality and performance, and development of screening techniques suitable for use in breeding programs.
4. Training of selected LDC personnel.

SIGNIFICANT FINDINGS: Research efforts have been concentrated on obj. 2, 3, and 4. Optimal germination temperature range (20-30C) has been determined for 36 sorghum lines. Genotypic variability was found above 38C and at 16C or below. Responses to temperature appear to be determined by genotype and conditioned by physiological quality of the seed. Temperature profiles (time/%) for germination of the 36 lines were established. Germination/emergence of 22 sorghum lines was also characterized in terms of soil moisture relationships. Responses at moisture tensions ranging from -0.1 to -10.9 atm indicated significant interactions between soil moisture tension and genotype, suggesting that screening for germination/emergence at -8.6 and -0.2 atm might be useful in selecting for "drought", and "wet soil" tolerate traits. Similar variability was also observed under osmotic stress conditions (PEG). A technique for establishing soil crusts has been developed to evaluate the effects of mechanical impedance on emergence. Preliminary observations indicate there is genotypic variability for emergence under mechanical stress. Seventy-five sorghum pure lines were evaluated for resistance to field weathering (in terms of germination/vigor) in 1980 and 1981 under ambient and supplemental "misting" conditions. Deterioration of the seed increased as time after physiological maturity increased, and was most severe under "misted" conditions. Genotypic variability was observed suggesting the techniques could be applied in a selection program for weather resistant sorghum lines. Three international students (Togo, Sudan, Brazil) are receiving training in sorghum seed research. A Swiss technician (employed by Swiss Int. Dev. Coop.) has arrived for training in technology of kinds of seed important in South America including sorghum. Work on obj. 2-4 is continuing. An effort under obj. 1 will be organized this spring.

INTSORMIL ANNUAL REPORT FOR 1981

Project Number: Mississippi State University, Project XII MSU-2a
Project Name: Sorghum Host-Plant Resistance and Genotype Evaluation
Personnel: Agronomy - Dr. Lynn M. Gourley, Leader, Dr. Norman C. Merwine, Dr. Jacque C. Denis
Overseas Linkages: Mexico, Honduras, CIAT-Colombia and Brazil
Major Objectives:

1. Incorporate factors for resistance to the sorghum midge and fall armyworm, grain mold, and leaf disease pathogens into elite U.S. and LDC food grain sorghum germplasm.
2. Evaluate and conduct inheritance studies on sorghums with multiple sources of tolerance to aluminum, manganese and low pH.
3. Conduct inheritance studies on multiple sources of resistance to sorghum insect and disease pests endemic to Mississippi and LDC's.

Significant recent findings:

A method for screening and testing sorghum genotypes for aluminum (AL) tolerance in nutrient solution, developed by Furlani and Clark, was used in a series of studies. In one study, 168 genotypes were screened for AL tolerance at 222 µmol AL using SC175-14 and TX 415 as tolerant and sensitive checks, respectively. Thirteen of these genotypes were classified as AL-tolerant. Two of these 13 genotypes also were classified by Duncan as AL-tolerant using an acid soil field screening. An R-line and B-line diallel were evaluated for Al tolerance and a significant portion of the variance was under genetic control. The variance due to GCA was greater than that due to SCA. Both diallels showed that additive and non-additive gene action were involved. A general lack of dominance was noted. Additional screenings of lines from the World Collection of Sorghums are underway. Field tests of AL-resistant lines in Colombia have been planted. Several F_2 populations are being screened in the laboratory and in Colombia for AL-tolerant segregates.

Selections (160) from 8 F_2 families of ICRISAT food grain lines by disease resistant temperate lines from MS were planted in Mexico and Honduras in 1981. All of the 1818 selections from these families were grown in MS in 1981 and 425 selections from the best F_3 families were planted in Colombia and additional sets of these lines have been sent to Mexico and Honduras.

Using a mist fogger nozzle system to create artificial weathering conditions (1 hr/day) from flowering until one month past physiological maturity, 25 GWT lines from Texas were compared with 33 SEPON-79 white food grain lines from ICRISAT in 1980 and in 1981 tests. In the 1980 test, the white seeded SEPON-79 lines compared favorably with the GWT lines for initial germination percentage, field emergence, and seed membrane integrity as measured by the ASA-610 automatic seed analyzer. Several of the SEPON-79 lines should prove to be good sources of grain weathering resistant germplasm.

A sorghum line moderately resistant to the fall armyworm, 1821 c.m., and a susceptible check, Huerin Inta, have been identified. The genotype 1821 c.m. from the CIMMYT collection is a feterita from the Sudan. With these checks, 36 additional lines were evaluated in field and greenhouse trials in MS and GA for resistance to fall armyworm damage. Several SEPON-79 entries from ICRISAT and a few other entries show promise as additional sources of resistance. Screening and inheritance work will continue in the U.S. and field trials will be established in Mexico, Honduras, Colombia and Egypt.

Based on 1980 and 1981 data on laboratory emergence of live midge, there were 5.1 and 6.4 times as many midge emerging from chasmogamous-indurate glume sorghums as from the cleistogamous line S67-1 (papery-rolled glume), respectively. The advantage for S67-1 was 2.5X to 16X and varied with date and intensity of midge pressure at the time of anthesis. Numbers of midge emerging from S67-1 did not differ from TAM 2566, the resistant control.

Sorghum R and B lines (82) and hybrids (46) from Mississippi were evaluated in MS and GA for midge resistance. From TX, 40 lines and 20 hybrids also were evaluated at at both locations. Several of the MS R-lines with resistance produced resistant hybrids using TX resistant A-lines. Hybrids from MS resistant A and R-lines will be increased in 1982 for testing in the U.S. and overseas.

INTSORMIL ANNUAL REPORT FOR 1981

Project Number: Mississippi State University, Project XII MSU-2b

Project Name: Sorghum Host-Plant Resistance and Genotype Evaluation

Personnel: Entomology - H. N. Pitre, Entomologist (MS)
B. R. Wiseman, Entomologist (GA)

Overseas Linkages: Mexico, Honduras, CIAT-Colombia and Egypt

Major objectives:

1. To evaluate sorghum genotypes for resistance to the fall armyworm and sorghum midge.
2. To study aspects of the biology of the fall armyworm in relation to sorghum genotypes to obtain information useful in host plant resistance studies.

Significant research findings:

Fall armyworm field screening. Using a moderately resistant line, 1821 c.m. identified by Wiseman from the CIMMYT collection, and a susceptible check, Huerin Inta, 36 additional lines were evaluated in two field trials in Georgia. Sorghum plants in the early whorl (3 reps) and late whorl (6 reps) were infested with 10 larvae/plant in two applications. Data for damage ratings showed general concordance between the rankings of the two tests. Several SEPON-79 entries from ICRISAT and a few other entries indicated levels of resistance equal to 1821 c.m. These 38 lines were evaluated in Mississippi under natural infestation in the field. There were no significant differences in number of larvae plant. Field trials of these lines will be established in Mexico, Honduras, Colombia and Egypt.

A damage rating scale for fall armyworm feeding on sorghum at different phenological growth stages was developed in Mississippi to emphasize whorl leaf feeding damage without equally weighting old damage on outer leaves (Scale moves 0 to 6 in .5 value increments).

Armyworm oviposition. Eight lines, 4 with normal bloom (wax) and 4 near isogenic lines with low-bloom, were evaluated in field cages. There were no differences in number of eggs/plant. Egg laying preference on crops was ryegrass > wheat > corn > sorghum > cotton > soybean.

Fall armyworm greenhouse screening: Thirty eight sorghum lines in the early whorl stage (27 da) were evaluated for susceptibility to mass fall armyworm feeding in the greenhouse. Neonate larvae (3/plant) were released (using bazooka and corn cob grit0 on plants growing in rows (12 plants/row) in flats (38 lines/flat). Feeding damage (1 4 da) ranged from 50-98%. Twenty lines were evaluated in a second test as above with similar results, however damage ranged from 21 to 61% with 16 lines under 40%. (Greenhouse studies in progress in Mississippi and Georgia.)

Armyworm development: Larval developmental periods on 9 selected sorghum lines of different morphological and/or physiological types were evaluated in the greenhouse. Plant material was fed to larvae; larval developmental period and pupal weight were recorded. High lysine and high tannin had significant adverse affects on development of the larvae, but pupal weight was not affected.

Midge: Four midge trials, 2 line and 2 hybrid, each were evaluated in Mississippi and Georgia in 1981. Sorghum R and B-lines (82) and hybrids (46) from Mississippi and 40 lines and 20 hybrids from Texas were rated for midge damage. Several of the Mississippi R-lines with resistance produced resistant hybrids using Texas resistant A-lines. Hybrids from Mississippi resistant A and R-lines will be increased in 1982 for testing in the U.S. and overseas.

INTSORMIL ANNUAL REPORT FOR 1981

Project Number: Mississippi State University, Project XII MSU-2c

Project Name: Sorghum Host-Plant Resistance and Genotype Evaluation

Personnel: Plant Pathology - Dr. Stanley B. King, Dr. Natale Zummo, Dr. Larry E. Trevathan

Overseas Linkages: Mexico, Honduras, CIAT-Colombia, Brazil and ICRISAT-India

Major Objectives:

1. Identify resistant sources to leaf, stalk and root diseases in sorghum.
2. Determine the etiology of the sorghum disease complex in which *F. moniliforme* is generally associated.
3. Evaluate white seeded food grain sorghum germplasm for resistance to grain mold and weathering in tropical and temperate environments.
4. Provide limited quarantine service for MSU and other INTSORMIL projects.

Significant recent findings:

Grain sorghums, including 8 SEPON-79 food grain varieties, were grown with and without misting during grain development and evaluated for grain mold based on appearance, frequency of fungal invasion, and ergosterol content. Grain mold increased significantly from physiological maturity to harvest maturity, regardless of evaluation method. Ergosterol analysis (indicator of fungal growth in grain) revealed greater differences among varieties than plating seed for infection frequency. Visual assessment of grain mold was more closely correlated with ergosterol levels than with total fungal colonies isolated or invasion frequency.

Isolations from roots of field-grown sorghum revealed the frequency of *Trichoderma*, *Curvularia*, *Macrophomina*, *Penicillium*, *Fusarium*, *Periconia*, and *Nigrospora* fungal species to be high in sorghum root systems showing deterioration. A possible new race of sorghum rust in Louisiana and anthracnose in Georgia were found. New sources of MDM resistance in sweet sorghum were reported, and possible resistance to rough leaf spot and yellow sorghum stunt were also identified. Additionally, a nematode species, tentatively identified as *Quinisulcius curvus*, has been consistently associated with diseased sorghum root systems.

The program will continue to be directed toward identification of resistance to organisms which incite leaf disease, grain mold, and root system deterioration of sorghum. Seed of food grain lines from the International Sorghum Grain Mold Nursery of ICRISAT will be evaluated for ergosterol, an indicator technique for grain mold not available to ICRISAT. A formal manuscript on bacterial soft rot of sorghum and millet will be published in 1982. Research will continue to be directed toward determining the correlation between insect vector prevalence and the occurrence of MDM and MCD in the United States. The chronological order of occurrence of predominant fungi will be determined in relation to roles in root system deterioration. The pathogenicity of these organisms, both alone and in combination, will be assessed. The role of the recently isolated nematode species mentioned above, both alone and in combination with primary fungal pathogens, in the sorghum root disease complex will also be investigated.

Selections (425) from the best 1818 F_3 families of ICRISAT food grain lines by disease resistant temperate lines from Mississippi were planted in Colombia and additional sets have been sent to Mexico and Honduras. This material will be evaluated for agronomic type and grain mold resistance and the best F_5 lines will be evaluated under artificial weathering conditions (misters) in Mississippi in 1982.

A Spanish speaking Ph.D. candidate is scheduled to complete a portion of his research in CIAT-Colombia. The research involves the study of root and stalk pathogens and nematodes associated with normal and low pH, high-aluminum soils in Colombia.

Project Name: An Interdisciplinary Approach to Nutrition Improvement of People Consuming Grain Sorghum and Pearl Millet as the Staple Food.

Project Number: XII-MSU-3A

Personnel: Dr. Mary Futrell, Leader
Dr. Lois Kilgore

Overseas Linkages: Secretary of Natural Resources - Honduras

Major Objectives:

1. To determine consumer preference for sorghum according to color, variety, flavor, seed size; and how these grains are processed and prepared for family consumption in southern Honduras.
2. To determine the social, economic, and local dietary factors that affect the food habits of people in Honduras.
3. To begin a surveillance program to monitor malnutrition which will be used as a yardstick for assessing progress of agricultural development.

Significant Recent Findings:

This interdisciplinary research dealt with the agronomic, economic, social, and nutritional factors which influenced the production, storage, preparation, and consumption of sorghum in southern Honduras. An interview schedule covering the above areas was used by Mississippi INTSORMIL researchers in May 23 - August 2, 1981 in mountainous Corpus and Guajinquil and lowland area of Pavana of southern Honduras. Food intake studies, as well as anthropometric measurements, were used to assess the nutritional status of each child under six years of age.

Twenty-nine percent of the families in Corpus, 80 percent in Guajinquil, and 37 percent in Pavana were using the traditional tall white varieties of sorghum for tortilla making. Other uses of sorghum (maicillo) for food as well as tortillas were recorded in detail. Both ashes and lime were used in tortilla making and varied according to villages. Methods of grinding and times of steeping also varied. There did not appear to be a strong bias in favor of corn tortillas over sorghum on the grounds of higher prestige but rather on the basis of taste, texture, and appearance. Food intake data revealed that every adult interviewed ate tortillas daily (corn - 30 percent, sorghum -45 percent, and mixed - 25 percent) and 92 percent ate beans. The sorghum tortillas observed were heavier, darker and more grainy in texture than corn tortillas. Sorghum was used more for tortillas during the last two months of the dry season and the beginning of the wet or planting season. New varieties of sorghum with more desirable characteristics for tortillas would be well received.

Food attitudes of the mothers revealed a bias against high protein foods such as meat and beans and green vegetables for children. This data indicated that a nutrition education program for mothers would be helpful. Anthropometric measures of children under six were used to assess the degree of malnutrition in the area. Thirty-five percent of the children were normal, 36 percent were 90-76 percent of standard, 24 percent were 75-61 percent of standard, and 5 percent were less than 60 percent of standard. These results agree with the recent Hondurian nutrition survey. The relationship of malnutrition, social, and economic factors are being assessed.

Project Name: An Interdisciplinary Approach to Nutrition Improvement of People Consuming Grain Sorghum and Pearl Millet as the Staple Food.

Project Number: XII-MSU-3B

Personnel: Dr. Mary Futrell, Leader
Dr. Louis Bluhm
Eunice McCulloch

Overseas Linkages: Secretary of Natural Resources - Honduras

Major Objectives:

1. To study the interrrelationship of social, economic, and agronomic factors in the subsistence farming systems where grain sorghum is produced and consumed in southern Honduras.
2. To assess the possibility of an improvement in nutrition and economic status of these farming families through the adoption of improved varieties of grain sorghum.

Significant Recent Findings:

Exploratory research conducted in southern Honduras where sorghum is grown for human consumption has produced valuable data concerning these subsistence-level farming systems and related social variables.

In the areas visited, the prevailing type of family unit is that of the nuclear family. A typical household consists of 5 persons living in a one-room house with an earthern floor, the kitchen area occupying either a part of one wall or an attached lean-to structure.

Work roles are typical of traditional Latin American areas: men do the field work, women are chiefly occupied with household chores such as preparing food, carrying water, caring for children and are responsible for small animals. Women sometimes help in the fields but this is not viewed as a regular duty. A few women engage in market activities by baking breads, particularly in the food shortage season when extra income is badly needed.

Agricultural methods are primitive--the machete and digging stick are used in the mountains; in the lowlands, plowing is done by oxen and a wooden steel-tipped plow. Farms are very small (generally less than 3 acres). Land tenure includes ownership, rental, free usage and cooperative leagues. Sorghum is seldom planted by itself but is interplanted with corn or with corn and beans. There are three systems of interplanting: alternate plants of corn and sorghum, alternate rows of corn and sorghum, and both planted in the same hole. The most prevalent sorghum crop disease encountered resembled zonate leaf spot. Field insects were not a serious problem in the mountains but caused serious root damage in the lowland area. Insecticides and fertilizers are not used on the fields. Grain storage methods are inadequate to prevent serious loss from insects in spite of the use of insecticides in stored grain. Because of land shortage and permanent cropping, soil fertility is becoming an increasing problem.

Grain sorghum is valued because of its reliability and the flexibility it affords in dates of planting. Because of seasonal labor and food requirements, long growing season varieties of grain sorghum appear to be favored.

INTSORMIL PROJECT SUMMARY

Project Name: Physiological Methods of Selecting for Drought Resistance in Sorghums.

Project Number: INT UN-1

Personnel: C. Y. Sullivan, J. D. Eastin, D. G. Watts, W. M. Ross, C. A. Francis, A. Retta, C. Caha, L. Pavlish, R. Wilson, J. Harcourt, C. Sodhi, M. Traore.

Objectives: (1) To define physiological characteristics which are affected most by drought stress, and identify both tolerance and avoidance mechanisms which may be selected to improve drought resistance.

(2) To develop and implement practical techniques of screening and selecting for plant genotypes with desirable physiological responses for use in breeding for yield stability in moisture stress situations.

Significat recent findings:

Fifteen genotypes, selected for a range of drought resistance responses when grown on an irrigation gradient in sandy soils and by other controlled environment tests, were grown hydroponically in plastic tubes in a greenhouse. By withholding water and lowering the water table in the tubes, it was shown that genotypes possess potentials for different depths of rooting. The technique holds promise for screening for ability to deep root. Field root samples and soil water depletion patterns were taken for part of the genotypes for a comparison of field and hydroponic rooting characteristics. Processing of the field samples is incomplete but will be finished in the coming weeks.

In similar hydroponic experiments with hybrids RS 671 and three experimental hybrids when only 20% of the root systems were in contact with water photosynthetic rates were not reduced, although grain yields were reduced by about 30%. When about 10% of the root systems were in contact with water photosynthesis was reduced 20 to 30%. Mean total root dry weight was reduced by 11%, although depth of rooting increased by 11% in the water stressed plants. In comparing the water use efficiency on a total dry matter vs water transpired basis, efficiency of stressed plants increased by 14% compared to controls. However, WUE for grain produced decreased in every case. This reduced efficiency ranged from 38 to 7%. Hybrid RS 671 was the least efficient and MW X 8569 had the highest efficiency. Results indicate that this is a feasible method to screen for WUE. A technique of screening for seedling drought tolerance was also developed. Genotypes differed in ability to maintain photosynthesis when under stress in the seedling stage.

Comparing tropically and temperate adapted hybrids under irrigation showed the tropically adapted types yielded 20% more than the temperate types. Under dryland conditions the yield difference was only 6%. Greenhouse grown tropical hybrids showed continued carbon uptake when water stressed whereas the temperate hybrids did not.

FORMAT FOR INTSORMIL PROJECT SUMMARIES (Jan. 1982)

Project Name: Grain sorghum and millet response to temperature Project Number: XII UN

Personnel: J. D. Eastin, C. Y. Sullivan, C. F. Francis, M. D. Clegg

Overseas linkages: Students - S, Resident Scientists - RS
Mexico: V. Gonzales and J. Gomez (S); V. Guiragossian (CIMMYT), A. Betancourt and E. Romo (R.S.). India: A Dhopte (S). Philippines: J. R. Santos (S). Egypt: A. Shehata, Fakri Fayed.

Major objectives:

1. Compare corn and sorghum responses to water-stress and temperature variables two locations.
2. Evaluate sorghum grain yield responses to night temperature at two water levels.
3. Evaluate water x temperature interactions on sorghum grain yield and yield components in growth rooms.
4. Attempt clearer morphological definition of panicle development when pistil and stamen primordia are forming and expanding to set the seed number component of yield.
5. Evaluate temperature effects on root growth.
6. Initiate experiments on mulch tillage effects on yield, soil temperature, root growth and evapotranspiration.
7. Continue comparative sorghum-millet research.
8. Continue drought screening work in Western Kansas and Western Nebraska.

Significant recent findings: (1) Sorghum-corn comparisons relate to crop choices to be made in areas like portions of Kenya, Tanzania, Mexico, etc. Data trends for 1981 were generally similar to previous years indicating water use efficiencies for sorghum are higher when conditions dictate yields below 5 to 6 T/ha. (2) Night temperature control field experiments at two water levels (Garden City, KS) were partially successful. A field water difference at floret differentiation (FD) + 7 days did not materialize and yield reduction due to night temperature differences were marginal (≤15%). However, water deficits during the second week following FD reduced grain number and yield. (3) Growth room tests in soil at 30, 35 and 40 C day temperatures (22 C night) showed 35 C to generally be most optimal with modest or no water stress. Elevating temperature to 40 C reduced yields 18% below maximum. Withholding water 6 days before FD until 3 days and 6 days after reduced yields 15 and 30% respectively at 35 C and 40 C compared to 30 C giving an obvious water x temperature interaction. (4) Stress imposed yields reductions usually correlate with seed number reductions forced during floret development presumably from floret abortion or lack of floret formation. Morphological development tracing was not successful in terms of distinguishing between formation and abortion problems but did yield outstanding detail on floret development. (5) Root elongation rates from 18 C to 36 C ranged from 0.82 to 2.41 cm 1 day, respectively. Knowledge in this area needs to be expanded and correlated with root exploration depth in relation to water extraction potential in conventional vs. cooler mulched soils associated with reduced or no tillage. This could be particularly critical in high altitude, low rainfall areas. (6) The practical end of combined water-temperature effects on yield and yield-related functions (root growth, water impounding, evapotranspiration, etc.) is being studied at Sidney, Nebraska, a dry (about 400 mm) medium elevation (1300 M) area. The research approach initiated in 1981 included rotations and monocultures handled in conventional bare soil, subtilled soil, and no tilled soil at several water levels. (7) Comparative sorghum-pearl millet research indicates millet has some yield-limiting developing problems but has some desirable photosynthesis and transpiration characteristics. Photosynthesis and transpiration measurements show that the ratio of photosynthesis to transpiration (assimilation efficiency ratio) is about the same for sorghum and millet at 30 C but tends to increase up to 42 C for millet and decline for sorghum which may relate to its utility in very hot, dry environments. (8) Drought screening studies on S_1 lines of 3 populations were initiated at Garden City, KS. Results will accumulate over the next several years.

FORMAT FOR INTSORMIL PROJECT SUMMARIES Jan. 14, 1982

Project Name: Grain Fill Period in Sorghum Project Number: XII UN 3

Personnel: C. A. Francis, J. D. Eastin, M. D. Clegg, W. M. Ross

(NOTE: Project funding was discontinued July 1, 1981)

Overseas linkages: Primary research activity conducted by graduate student from national sorghum program, Tanzania; other activities carried out by students from Sudan and US -- latter now with ICRISAT in India.

Major objectives: The overall objective of project UN 3 is to focus on the critical grain fill period in sorghum. Specific activities explore the relative importance of rate of grain fill versus time of grain fill, the genetic variation which exists for both rate and time of filling, and the effects of stress conditions on grain fill. Stated objectives are:

1. Explore existing variation in grain fill period under a range of conditions and relate this to other morphological and physiological characters.
2. Develop new lines and source populations with modified grain fill periods and/or rates of fill.
3. Test these new lines, hybrids and populations in a wide range of temperate and tropical zones.

Although funding for this specific project was discontinued in July 1981, the major activities are continuing under the companion project UN 4. Most important among the continuing activities include selection of extremes in grain fill rates and times in lines and random mating populations, study of the effects of stress conditions on grain fill and yield stability, and the testing of materials over environments.

Significant recent findings:

Over a range in environments (48 sites in Nebraska and Kansas), there are striking differences in the grain fill period in a standard set of sorghum lines and hybrids. Conclusions from the work are specific to maturity groups. In early hybrids, there is a proportionately greater length of the total growth cycle spent in the fill period as compared to later hybrids. In early hybrids, there is a lower rate of grain fill (12.5 kg/ha/GDD) than in later hybrids (14.4 kg/ha/GDD). Within the early hybrid group, there is a highly significant positive correlation with length of GS1 and GS2, and a highly significant negative correlation with length of the fill period when expressed in growing degree days. The opposite relation is true of late hybrids. There appears to be more variation in length of GS1 and GS2 than in GS3, although sufficient variation exists to make genetic change.

FORMAT FOR INTSORMIL PROJECT SUMMARIES Jan. 14, 1982

Project Name: Adaptation and Yield Stability in Grain Sorghum Project Number: XII UN 4

Personnel: C. A. Francis, J. D. Eastin and W. M. Ross

(Note: Some activities of UN 3 are included in this project after July 1,1981)

Overseas linkages: Field testing of sorghum genotype x location and genotype x cropping system interactions is currently under way in Tanzania; principal research activities have been carried out by students who are now in Colombia, Tanzania and India, and one of whom will soon return to Pakistan.

Major objectives: The global objective of this project is to explore the genetic and climatic factors which relate to adaptation and yield stability in sorghum. Specific activities involve testing over locations, dates of planting, water levels, tillage systems and cropping systems to evaluate the interactions of genotype with each of these climatic and cultural variables. Stated objectives of the project are:

1. Study the adaptation and yield stability of a range of grain sorghum lines and hybrids under varied climatic conditions.

2. Determine which morphological and physiological traits are associated with stability of yield.

3. Develop widely adapted populations for use as varieties and as a genetic source for extracting lines.

4. Test widely adapted lines, hybrids and populations in a range of climates and cultural conditions in temperate and tropical zones.

Several thesis projects have been concluded which relate directly to adaptation and yield stability. Screening large numbers of materials for tolerance to extremes in temperature and moisture continues in the test locations, and synthesis of populations from the selected lines is under way in Sidney. In cooperation with KSU, testing of half-sib families of pe rl millet has been done in two locations in Nebraska. Specific tolerance to short season and cold temperatures is a breeding objective of this work in Western Nebraska, traits that could be useful in higher elevations where rainfall is limited in the tropics.

Significant recent findings:

Specificity of adaptation to locations, planting dates and cultural systems continues to present a unique challenge to breeders. Although seed number per m^2 is the component of yield most closely related to yield per ha, it appears that seed size may be the component most related to stability. In poor environments, all three components (heads/m^2, seeds/head, seed weight) are greater in stable than in unstable genotypes. Higher temperatires during GS2 reduced the GS2 period and gave fewer seeds/m^2. However, the reduced GS2 period lowered yields in unstable hybrids but not in stable hybrids. Tolerance to stress conditions in the expression of each yield component may be more important that compensation among them in reaching stability of yield. The relative time spent in each growth stage also varies among maturity groups, and the route to increa ed yields by manipulation of this growth cycle appears to differ drastically between early and late hybrids. Although early hybrids are more efficient in grain production per GDD of total growth cycle, late hybrids appear to be more efficient per GDD in the filling period. Further work needs to be done.

1981 INTSORMIL PROJECT SUMMARY

PROJECT XII UN-5 Mineral Element Efficiencies and Tolerances in Sorghum and Millet

Personnel: R.B. Clark, J.W. Maranville, W.M. Ross, and R.A. Olson

Overseas Linkages: Dr. Clark is a cooperator on a project with Dr. N. Seetharama, ICRISAT, India; Team trips have been made to Egypt, Botswana, Sudan, Mali, Colombia, Mexico, and Philippines to engage cooperative research; Dr. Maranville will be going to the Philippines for a year, starting in June; Students are now being trained from Algeria, Philippines, Tanzania, Sudan, Nigeria, Colombia and Botswana, and recent students have returned to Egypt, Iraq, Tanzania, Yugoslavia, Turkey, India, Peru, Nigeria, and Brazil; Recent visits were made to Sri Lanka, Iraq, India (ICRISAT, Punjab Agric. Univ., and Lucknow Univ.) and Philippines (IRRI) for special symposia, consultations, and to encourage cooperative research.

Objectives: 1. Evaluate genotypic responses for efficiency and tolerance to uptake, translocation, distribution, accumulation, balance, and use of mineral elements of plants grown in high, normal, deficient, and toxic root environments; 2. Determine the adaptability and stability of genotypes grown on soils with varied mineral stresses; 3. Determine effects of environment, production, and management conditions on uptake and use of mineral elements; and 4. Determine the inheritance of mineral element efficiency and toxicity tolerance traits.

Significant Results: Relatively rapid and inexpensive methods for screening sorghum genotypes for tolerance to mineral element deficiencies and toxicities in nutrient solutions have been developed and evaluated. Treatment variables that gave wide differences among genotypes were 10 mg N/plant for low N; 2 mg P/liter for low P; 12 mg P/liter or NO_3^- as the source of N to induce Fe deficiency; and 4 mg Al/liter with 2 mg P/liter for toxic Al. Preliminary results indicate that the methods can also be used to screen sorghum genotypes for high and low Mn tolerances. Diversity among inbred lines and S_1 progenies of populations for low N and P, Fe deficiency, and Al toxicity was sufficient to suggest that progress in the improvement of sorghum for tolerance to these element stresses should be feasible. Parameters used to assess plant responses to these element traits were better defined. Plants exhibiting wide variations to these elements showed differences in element uptake rates, root phosphatase activities, distribution among plants parts, and concentrations and balances of interacting elements. Comparative results of laboratory and field screening pointed out that even though field responses were complex they were generally related to laboratory results. In Al toxicity studies using nutrient solutions, concentration of Al may be lower than those observed under field conditions and genotypes screened for Al toxicity in the laboratory may require several levels of Al and other soil acidity factors may require investigation (e.g. high Mn or Fe, low P or Zn) before close relationships are obtained. Initial inheritance studies indicated that Al tolerance depended more on the male parent than on the female parent and that various cytoplasms had little effect on inheritance. Inheritance of Fe deficiency in sorghum may be more complex than that noted for dry beans which had 2 major genes for dominance or recessiveness. For the conversion of liquid (nutrient solutions and plant digests) to solids for EDXRF analysis, samples required passages through two ion exchange filter papers or two passages through the same paper to eliminate elements, except K, from solution.

1981 INTSORMIL PROJECT REPORT

Project Name: Nitrogen Uptake in Sorghum and Millet

Project Number: XII UN-6

Personnel: J. W. Maranville, R. B. Clark, C. A. Francis, J. D. Eastin

Overseas Linkage: Approximately one-third of this project budget is used to support one graduate assistant from the Philippines. It is anticipated that Dr. Maranville will be spending one year in the Philippines working directly in mineral element efficiency improvement. Dr. Clark has laid some groundwork with scientists at IRRI and the UPLB for this project. Work is now being summarized for the millets for use by Dave Andrews in their program at ICRISAT with respect to nitrogen uptake and use. One student from Botswana who has recently arrived and one from Columbia will do their research on nitrogen.

Objectives: 1. Identify sorghum and millet genotypes which are capable of producing high rates of growth and good quality grain under limited N fertility. 2. Determine the physiological mechanisms which allow genotypes to be N efficient in comparison to those which require substantial N fertility to produce adequately. 3. Measure the interactions which occur in N metabolism and environmental parameters such as light, temperature, and water.

Significant Findings:

The magnitudes of nitrogen efficiency values for sorghum varied depending on the environment under which the samples were taken. Generally, field grown samples produced values markedly lower than samples grown in nutrient solution under greenhouse conditions. Samples taken from soil pots in the greenhouse were also much higher than those from the field. In most instances, however, those found to be better in the field were also better in the greenhouse. Metabolic nitrogen efficiency values were much higher on less fertile soils or for unfertilized conditions. Sorghum apparently does a better job of remobilizing nitrogen for growth if less N is available. Yields, however, are sacrificed. New terms were introduced which places more emphasis on yield. In this case, nitrogen efficiences were higher for more fertile conditions. The new terms (utilization efficiences) appear to provide a better selection criteria than those previously proposed (metabolic efficiencies). Millets tested in 1981 (foxtail, proso, and pearl) were found to be less efficient in converting nitrogen to dry matter yields than sorghum. This was due to less total yield and higher concentrations of tissue nitrogen at harvest. Foxtail millet was slightly better in metabolic N efficiency than pearl, and considerably better than proso. However, when total yield was taken into account (utilization efficiency), pearl millet was markedly superior to the other millets, but still inferior to the better sorghums.

INTSORMIL PROJECT SUMMARY

Project Name: Recurrent Selection in Sorghum **Project Number:** XII UN 7

Personnel: W. M. Ross, C. O. Gardner, and C. A. Francis

Overseas Linkages:

Louis Mazhani, M.S. student, Botswana; A. B. Mohamed, Ph.D. student, Sudan; C. I. Flores, Ph.D. student, Philippines; and Dr. J. W. Maranville, who has applied for a visiting professorship at the Univ. of the Philippines-Los Banos.

Major Objectives:

1. Develop random-mating populations possessing attributes of high yield, desirable agronomic and physiologic traits, pest resistance, and grain quality.

2. Apply recurrent selection techniques to populations; identify efficient breeding methods.

3. Select useful germplasm from improved cycles of recurrent selection.

4. Study enzyme genotypes in random-mating populations to: a) assess the amount of genetic variability, b) determine the extent of outcrossing in the mating system, and c) relate enzyme genotypes to yield increases, pest resistance, drought and heat tolerance, and other traits.

Significant Recent Findings:

Three types of family selection (half-sib, full-sib, and S_1) are being evaluated in NP3R. C_3 families were grown in 1981 and will be retested in 1982. To date, S_1 progeny testing appears to be the most practical means of increasing yield. It also has been effective in increasing resistance to European corn borers in NP11BR through three cycles though gains have been only moderate due to the trait's complex inheritance. S_1 progeny testing is being applied to improve mineral efficiency (Al toxicity) and disease resistance (anthracnose). Small mean differences in yield, height, and flowering were detected in families taken three years from the same base of NP16BR when tested over two years. Ample variation existed in each set of families, however, so as not to effect recurrent selection. Populations can be fruitful sources of inbred lines as illustrated by the fact that 10 R-lines each selected in Arizona and Nebraska from NP3R produced higher yielding hybrids than 10 selected, Nebraska-adapted, component R-lines of NP3R tested over four environments (4662, 4605, and 4421 kg/ha, respectively, for Arizona, Nebraska, and component lines).

First-year studies were grown in 1981, but data are not analyzed for the following experiments: a) mass selection for increased seed size and increased yield in NP21R, b) evaluation of S_1 progenies from NP20BR for grain quality, c) evaluation of A-line X S_1 progenies versus their respective S_1 progenies in NP3R, and d) effect of family numbers on estimates of means and variance components using three family selection systems in NP3R. Preliminary investigations with S_1 progenies from two other populations suggest that 120 families from a population may be adequate for yield evaluation and retain adequate variability for genetic advances.

Electrophoresis techniques known to be successful with maize were tried on sorghum with mostly negative results. Further modifications are needed to

FORMAT FOR INTSORMIL PROJECT SUMMARIES

Project Number: XII UN 8

Project Name: Agricultural Climatology of Sorghum NU 8

Personnel: R. E. Neild, Principle Investigator

Joanne Logan, Graduate Student
M.S. The Agroclimatology of Grain Sorghum Hybrids Adapted to the Great Plains.

Ph.D. Phenology of Grain Sorghum as Related to its Potential in Cropping Sequences in the Tropics.

Arnel Cardenas, Graduate Student
M.S. Precipitation Probabilities as Related to Cropping Sequences Involving Sorghum, Millets and Other Crops in the Tropics.

Overseas Linkages

1. Philippine Council for Agricultural and Resource Research - Arnel Cardenas.

2. Tanzania - Collection of phenological data on grain sorghum and proso millet with -

   Gaudens Mitawa, INTSORMIL Ph.D. Student.
   Charles Francis, Supervisor and Collaborator.
   Henry Leyna, Title XII Beans Ph.D. Student.
   Dermot Coyne, Supervisor and Collaborator.

3. Columbia, Mexico, Dominican Republic - all tentative involving Joanne Logan.

Major Objectives:

1. To describe the growing cycle of grain sorghum in terms of climatic requirements. Critical stages of plant development and critical levels of significant elements would be identified and discussed.

2. To complete a comparative climatological analyses of sorghum growing seasons and regions in the United States and other developed countries.

3. To characterize and categorize the climatic conditions in seasons and regions growing sorghum in developing countries throughout the world. Emphasis would be placed on identifying areas where sorghum is grown beyond the limits normally considered as suitable for strains adapted to the developed growing regions.

4. Construct weather crop models to predict the development and yield of grain sorghum.

Significant Recent Findings:

1. Parameters have been developed to determine the expected time and precipitation associated with critical phenological stages and farming operations of grain sorghum in temperate and tropical regions.

2. Computer procedures have been developed to calculate daily temperature, growing degree day, precipitation and evapotranspiration data from monthly climatic summaries.

3. These parameters and daily climatic data are used to:

   a. Determine the time and length of growing season.
   b. Study the phenological response of different sorghum maturities at different planting times.
   c. Study the potential and most optimum position of sorghums and millets in cropping sequences.

4. A comparative analysis of sorghum growing seasons and regions in United States has been completed.

FORMAT FOR INTSORMIL PROJECT SUMMARIES

Project Name: Sorghum Virus and Stalk Rot Diseases

Project Number: XII UN 10

Personnel: Dr. S. Jensen

Overseas linkages:

Domestic linkages are with workers in Nebraska and Texas and internationally with cooperation from ICRISAT and CYMMIT. Correspondence is active with both areas. Visitation was made to CYMMIT to participate in the sorghum disease shortcourse and cooperative training in plant pathology is being started with three African students at the University of Nebraska.

Major objectives:

1. Describe the host genotypes that control the reaction of sorghum and millet to the major strains of sorghum viruses.

2. Identify the different genes and the potential breeding lines that can be used to impart resistance to the major strains of sorghum viruses.

3. Determine genetic linkages between genes for resistance to these sorghum viruses.

Significant recent findings:

This project was just initiated in mid-1981 so no great amount of work has yet been completed. A technician was hired in October so progress has been more rapid since then. Initial emphasis is being placed on the reaction of sorghum to strain B (a non-johnsongrass strain) of MDMV since some work is being done on johnsongrass strains in Australia in addition to the work in Texas. Several collections of germplasm have been tested and of 157 lines and hybrids 128 developed mosaic symptoms, 47 red stripe symptoms and after chilling 55 produced red leaf symptoms. The hybrid Asgrow Bugoff, which is an excellent diagnostic sorghum for the identification of MDMV-B, was selfed. The progeny are segregating into at least 5 to 6 classes where the hybrid shows only one reaction type-mosaic turning to red leaf upon chilling. It appears that small red fleck or streak symptoms are characteristic of anything derived from Combine Kafir. Reactions to MDMV-B resemble those described for the johnsongrass strains but must be controlled by different genes or alleles since some lines react differentially to the two virus strains.

January 13, 1982

Project Number: XII PRF 1

Project Name:	Socioeconomics of the Production and Marketing of Sorghum/Millet
Personnel:	W.H.M. Morris, Lee F. Schrader, Mahlon G. Lang, Marshall Martin, Tom Whitney, Robert Wilson - Purdue University
Activity 1:	Overseas linkages: USAID Pest Management Project Senegal/Gambia, and Gambia Department of Agriculture.
Objectives:	Develop a methodology for evaluation of c/b of chemical treatment of pests in West Africa and provide c/b estimates to GOG and USAID.
Significant Findings:	Thesis expected by April 1982.
1982 Plan:	Will be terminated.
Activity 2:	Overseas linkage: Farming Systems Unit, SAFGRAD, Upper Volta.
Objectives:	1) Describe structure of a village to city marketing system; 2) Evaluate efficiency of grain marketing system; 3) Describe information transfer in grain marketing system; and 4) Quality intra-market and inter-market price variation.
Significant Findings:	Survey in progress.
1982 Plan:	Complete first survey and analyse it.
Activity 3:	No overseas linkage
Objective:	To develop a manual on the methodology for conduct and prompt analysis of baseline farming systems surveys in subSaharan Africa and provide the information to FSR projects.
Signficant Findings:	Manuscript typed in first draft.
1982 Plan:	Continue to develop the methodology of analysis with micro-computers in the field.
Activity 4:	Overseas linkage: C. Raynaut, University of Bordeaux and INRAN, Niamey.
Objective:	Minor support to analysis of a farming systems study with a history of change, in a sorghum/millet area of Niger.
Significant Findings:	The report, "Recherches Multidisciplinaires sur la Region de Maradi (Niger): Rapport de Synthese," C. L. Raynaut, University of Bordeaux II, Oct., 1980 (actually appeared in 1981). This forms a point of departure for the FSR of USAID Niger Cereals Project (starting in spring 1982).
1982 Plan:	Activity terminated.

Proposed New Activities for 1982/3

Firm:	(a) With SOMIVAC in the USAID Casamance (Senegal) Development Project to seek the constraints to increasing sorghum/millet production on small farms in a 1000-1200 mm rainfall zone. Two junior economists will participate. INTSORMIL funded activity will be in analysis of the data. (b) Reopen the subSaharan Africa agricultural document collection, with help of other project funds at Purdue.
Tentative:	(c) Awaiting an opportunity to collaborate with other INTSORMIL institutions in the Sudan. (d) Seeking an opportunity to collaborate with the Carlsburg Foundation (Copenhagen) in the introduction of a small industrial sorghum mill or mills in West Africa to see if this can increase the urban consumption of sorghum at the expense of imported rice or wheat.

January 13, 1982

SOCIOECONOMICS OF THE PRODUCTION AND MARKETING OF SORGHUM/MILLET

Purdue University

Our activities of choice are performed abroad or using data from abroad. Robert Wilson is expected to finish his thesis on pest management economics in the Gambia by April 1982. His data are being used in a linear programming model to estimate the benefits from use of seed dressings on millet and peanuts and fungicide spray on peanuts in a millet, sorghum, peanuts, rice production system (with small areas of maize and digitaria).

A study of sorghum and millet markets and prices in Upper Volta is now underway with the Farming Systems Unit of SAFGRAD. This study is designed to describe and evaluate the structure of the village market and its links to the urban market and to estimate the price differentials attributable to different qualities of the grain. Dr. Lang will spend two years with the unit in Upper Volta which will lead to the intensification of this research (probably using Farming Systems Unit Funds).

Based upon the Purdue West African research in Mali, Senegal and Upper Volta, Tom Whitney has prepared a manual on the methodology for conduct of baseline farming systems research surveys and their analysis.

Minor support was given to Claude Raynaut, anthropologist, of the University of Bordeaux to help in the analysis of the data on the french National Science Foundation (CNRS) on combatting the effects of drought in West Africa. This research in the Maradi region of Niger, in collaboration with the Agricultural Research Organization of Niger, is in the area of millet, sorghum, cowpea, and peanut production with an average rainfall of 5-600 mm. Millet and peanuts are ceasing to be the dominant cash crop in the area, with the millet being consumed and cowpeas replacing peanuts. The results of this work will

form a basis for departure for the Farming Systems Research by Purdue based on the Tarna station, Maradi for the USAID Niger Cereals Research.

It is proposed to collaborate with the USAID Casamance (Senegal) Agricultural Development Project in a 1000 mm and over. The collaboration will enable us to study the constraints to increased sorghum/millet production in this region. The work will be done with SOMIVAC (the local development organization) with our providing the methodology and instruction and paying part of the costs of analysis especially the part beyond the needs of SOMIVAC.

There is discussion on the best way to maintain and improve our West African document collection, currently closed due to lack of funds. It is expected that the projects with need to use the documents will contribute to maintenance of the collection.

There has been discussion on our collaboration in the Sudan and, if we could see ways to do this, we would be glad to do so.

One of the possible ways to increase sorghum consumption in subSaharan Africa is to prepare a stable, high quality sorghum flour in an industrial mill. CIDA and the Carlsburg Foundation are working on this in two different types of system. We are interested to attempt to catalyse setting up one of the Carlsburg system mills in Ouagadougou or Niamey and to see if the flour produced could substitute for imported rice or wheat (as bread). Historically there is a decline in per capita millet/sorghum production and consumption and a marked increase in the consumption of imported rice and wheat.

Project Number: XII PRF 2

Project Name: Studies on Mechanisms of Disease Resistance and Susceptibility and Screening for Improved Resistance to Fungal Pathogens with Emphasis on *Colletotrichum graminicola* (Anthracnose)

Personnel: Herman L. Warren

Overseas linkages: Egypt

Major objectives:

a. To increase the diversity of resistance to *Colletotrichum graminicola* by assaying the World Sorghum collections and develop methods of incorporating this resistance into agronomically adaptable lines.
b. To examine the inheritance of resistance to *C. graminicola*.
c. To determine the effect of anthracnose on nutritional and mineral composition of stover and grain.
d. To study the influence of seed and soil microflora on seedling emergence, vigor and disease development.

Significant recent findings:

Twenty-six sorghum cultivars were tested in the field for resistance to *Colletotrichum graminicola*, the causal agent of anthracnose. Of the 26 cultivars evaluated, 5 were hypersensitively resistant to leaf blight and also resistant to the head blight phase of anthracnose, however, only 1 were resistant to all phases of anthracnose, including peduncle infection. One line (IS 0466) exhibited a susceptible reaction but had a reduced number of lesions per plant which indicate a source of polygenic resistance. The inheritance of resistance will be determined for these resistant cultivars.

Leaf resistance was shown to be controlled by a single completely dominant gene in 954206, while at least two completely dominant, independent genes were present in IS 9569. It was found that the genetic backgrown of each parent apparently modified the level of leaf susceptibility of its progeny.

In another study, 23 cultivars were compared in the field for the effect of seed treatment on seedling emergence, seedling blight and grain yield. The effect of seed treatment on the percent emergence and blighted seedlings were significant for infected vs non-infected seeds, seed treatment vs no seed treatment and among cultivars. The effect of seed treatment on grain yield was significant only for infected vs non-infected seed among cultivars.

Survival of *Colletotrichum graminicola* on Sorghum Kernels. *Colletotrichum graminicola* survive on sorghum grain for 16 months at 4 and 24 C. Naturally infected kernels were plated on oatmeal agar and the percentage of infected kernels obtained. Some lines had up to 50% infected kernels. Infected seeds were planted in the greenhouse at 24 C. Plant emergence and seedling blight ratings were made 10, 20 and 30 days after planting. There were significant differences for resistance to seedling blight.

Project Number: XII PRF 3

INTSORMIL ANNUAL REPORT - 1982

PROJECT NAME: Development of Agronomically Superior Germplasm Including Varieties, Hybrids and Populations which have Improved Nutritional Value and Good "Evident" Grain Quality for Utilization in Developing Countries

PERSONNEL: Allen W. Kirleis and John D. Axtell

OVERSEAS LINKAGES:

Niger - Director General INRAN, Mr. Moussa Saley
Project Director Niger Cereals Project, Mr. Mohamane Salifou
Sudan - Food Research Center, Khartoum, Dr. Badi, Ms. Laila Monawar
Sudan - ICRISAT/Sudan Program, Dr. Gebisa Ejeta
Egypt - EMCIP/Dr. Khorshid, Dr. Ahmed Hassen Ali, Dr. Fakhry Fayad
ICRISAT/CIMMYT Sorghum Project - Dr. Vartan Guiregossian
CIAT - Dr. Douglas Laing

MAJOR OBJECTIVES:

1. Determine how sorghum is processed, prepared into food and consumed, under actual LDC conditions.
2. Devise standard procedures for preparing traditional village foods made with sorghum and use them to develop simple screening tests for use in breeding programs to predict grain food quality.
3. Conduct basic studies to determine what components in sorghum are related to the functional characteristics that constitute food quality.
4. Identify, develop and evaluate sorghum lines or mutants with improved nutritional quality and superior food grain quality using both chemical and biological methods.
5. Investigate the potential for developing varieties of sorghum with high nutritional value and good food properties for potential use as nutritional foods for young children, pregnant women and nursing mothers.
6. Train LDC personnel in cereal chemistry and plant breeding research.

SIGNIFICANT RECENT FINDINGS:

Grain Hardness Tests

Comparison of a number of methods for measuring sorghum grain hardness showed that the particle size index was a sensitive measure of the physiocomechanical properties of sorghum related to grain hardness. Other methods used to evaluate grain hardness (% vitreousness and kernel density) ranked the sorghum cultivars in an order similar to particle size index, but these indices were less sensitive and more time consuming. The % floaters method had about the same sensitivity as the % vitreousness or kernel density tests and required much less time. We feel that the floaters test is a simple and reliable procedure that could be used by plant breeders when screening for grain hardness.

The pearling index parameter was somewhat less sensitive than the particle size index parameter for measuring grain hardness. In addition the pearling index parameter was influenced by kernel size. That is sorghum grain with large kernel size had a lower pearling index as compared to grain with small kernels, given the same endosperm hardness.

Percent kafirin of protein, a chemical parameter that has been suggested as a means of measuring grain hardness, was poorly correlated with all other hardness measurements investigated.

Gel Consistency Measurements

As with most foods, texture of cooked sorghum gruels or porridges has been identified as an important factor in the consumer acceptance of traditional foods made with sorghum. For example, in West Africa, Tô (a thick porridge prepared from sorghum or millet flour and water) is consumed by hand, and as such requires that the texture of the product be stiff enough to enable one to scoop portions with the fingers but not stick to the fingers or teeth. We have developed a simple and inexpensive test cell which can be used on an Instron food testing

machine for making quantitative gel consistency measurements on sorghum or millet gruels. Our gel consistency work has shown less vitreous sorghum, with a soft endosperm texture, produce a gel or gruel which is quite sticky. Whereas, vitreous sorghums produce a gel which is quite firm. The advantages of our test cell over other types used for stickiness testing are: 1. it requires only 10 g of sorghum flour per test; 2. it has a large surface area compared to other adhension test cells thus, making it more sensitive; 3. it is a very lite weight test cell thus, it requires less "zero compensation" which allows the use of a more sensitive load cell; and 4. it is extremely inexpensive (costing less than $5.00) and can easily be constructed in the laboratory.

Sudanese Food Grain Nursery Evaluation

In 1980 work plans were developed and mutually agreed upon by the Agricultural Research Corporation (ARC) of the Democratic Rapublic of Sudan and INTSORMIL Title XII to initiate a project to define the chemical, physical, and physicochemical parameters that would characterize sorghum "grain food quality." In this cooperative project entries from Dr. G. Ejeta's (ICRISAT-Sudan) food grain nursery were to be evaluated for their milling and kisra (Sudanese staple sorghum food) making quality by Dr. S.M. Badi (ARC Food Research Centre, Khartoum North, Sudan). The chemical, physical, and physicochemical properties of these same samples were to be evaluated by INTSORMIL scientists. Twenty-one entries from the 1980 crop sorghum food grain nursery have been tested for : thousand kernel weight, % floaters, kafirin protein content, water soluble protein, soluble sugars, ash, protein fat, gel stickiness, alkali digestibility, and cooked gel consistency. However, the milling and kisra quality evaluations have not yet been completed. Thus, relationships between chemical, physical, and physicochemical properties and quality characteristics can not be determined at this time.

Yield of P-721 Derived Lines

A replicated yield trial of 35 high lysine opeque sorghum lines derived from mutant P-721 in comparison with 11 elite normal lines at two locations in Indiana has been completed. The mean grain yield of the three best high lysine opaque lines was 8,285 Kg/ha versus 8,348 Kg/ha for the three best normal lines. Mean protein and lysine contents of the opeque and normal lines was 8.88 versus 8.62 percent protein and 2.99 versus 1.94 percent lysine, respectively.

Sorghum Protein Digestibility

In vitro protein digestibility values for a fermented Sudanese infant food called Nasha were significantly higher than unfermented foods prepared from cooked sorghum flour. Standardized procedures for the preparation of Nasha were developed for utilization by nutritionists at Johns Hopkins in feeding experiments to be conducted at the Nutrition Research Institute in Lima, Peru. Purdue will supply the sorghum flour and prepare a drum-dried Nasha for the experiments in Peru. Also, a decorticated, extruded sorghum product has been shown to retain high protein digestibility IN VITRO and preliminary IN VIVO results look promising.

Training Programs

Ms. Laila Monawar - Food Research Center, Khartoum, Sudan
Mr. Osman Ibrahim - Agricultural Research Cooperation, Sudan
Mrs. Gloria Cagampang - Phillipines
Mr. Immanuel Monyo - Tanzania Sorghum Project - A.R.I. Ilonga
Mr. Seni Lubinza - Tanzania Sorghum Project - A.R.I. Ilonga
Mr. Lorrie Kitch - Niger Cereals Project, Kolo, Niger

FORMAT FOR INTSORMIL PROJECT SUMMARIES

Project Name: Enhancement of High-Tannin Sorghum Utilization Project Number: XII PRF 4

Personnel: Dr. Larry Butler, Professor of Biochemistry
Thomas Asquith, Graduate Student
Christine Izuno, Technician (not paid by INTSORMIL)

Overseas linkages: Characterization of High Tannin (Bird-Resistant) Sorghums: This is done on an informal basis with LDC scientists (e.g. John Scheuring, Mali, ICRISAT), with INTSORMIL colleagues (Rooney and Teetes, Texas A & M; Futrell, Mississippi State; Hoseney, Kansas State; etc.) and with other U.S. institutions working LDCs (e.g. Bullard of the U.S. Dept. of Interior, working on bird control in western Africa). We have a more formal agreement to collaborate with Drs. Jambunathan and Subramanian of ICRISAT, Hyderabad.

Major Objectives: Our overall objective is to minimize the antinutritional effects of tannin in high-tannin sorghums, while maintaining or enhancing the agronomic benefits of the tannins. Our specific objectives are: 1) To elucidate the chemical mechanisms by which tannins and related polyphenols exert their antinutritional effects; 2) To develop simple processing techniques which eliminate the antinutritional effects of sorghum polyphenols, and to integrate them into traditional methods of sorghum food preparation; 3) To elucidate the metabolic pathways by which polyphenols are deposited in sorghum seed, and to learn how to manipulate them by altering growth conditions and cultural practices to minimize bird damage and maximize nutritional quality; and 4) To characterize the chemical basis for the role of sorghum polyphenols in disease and insect resistance, and stress tolerance.

Significant recent findings: We have found that the level of tannin (flavan-3-ol polymers) in developing grain is somewhat lower than previously noted. Most flavan-3-ols are present as monomers and possibly dimers, and are polymerized to tannins when the seed is dried as it matures on the plant, or when immature seed is removed for analysis. This finding raises the possibility that flavan-3-ol monomers and dimers, as well as tannin polymers, may contribute to bird resistance. We have discovered a previously unreported flavan-4-ol monomer present in the seed and in leaf tissue of about 1/3 of the sorghum lines examined. We have tentatively identified this material as apiforol, and have elucidated its unique chemical properties (it is converted to the anthocyanidin pigment apigenidin under extremely mild conditions) and metabolic properties (it appears to be converted to another as yet unidentified flavan-4-ol as a result of infection or stress of the plant). We have found mild conditions where high-tannin sorghum is "detoxified" within a few hours. We are characterizing Group II type tannin, and find that in some respectis it differs drastically from conventional (Group III) tannin.

FORMAT FOR INTSORMIL PROJECT SUMMARIES

Project Name: Enhancement of High Tannin Sorghum Utilization Project Number: XII PRF 4

Personnel: Dr. John C. Rogler, Professor of Animal Sciences
Hector Rodriguez, Graduate Student
David Sell, Graduate Student
Fred Coker, Technician

Overseas linkages:

Mr. Hector Rodriguez, mentioned above, is from the Universidade National del Sur in Argentina. Also, contact has been made with Dr. Horacio Rostagno of the Universidade Federal de Vicosa in Brazil concerning the possibility of a visit to Purdue to discuss and conduct research in the area of antinutritional effects of tannins.

Major objectives:

The primary objectives of this portion of the project deal with the determination of the mode of action by which sorghum tannins exert their antinutritional effects and various means of overcoming or minimizing these effects.

Significant recent findings: Major findings can be summarized as follows: (1) Germination of sorghum grain for 5 days had little effect on the tannin content of high tannin sorghum (HTS) and resulted in reduced growth rate of rats fed either HTS or low tannin sorghum, presumably due to mold production. (2) Wetting of HTS with 0.1N ammonium hydroxide for 12 hours reduced the assayable tannin dramatically and improved growth rate of chicks up to a level equal to that of chicks fed LTS similarly treated. These results agree with our previous findings on detoxification of HTS with ammonia, but much lower concentrations of ammonia were used for a shorter period of time in the present study. (3) Increasing the nitrogen content of a low protein diet by adding a mixture of crystalline amino acids improved growth rate, but increased the difference between HT and LTS. This is in contrast to increasing the dietary nitrogen content with intact protein which reduces or overcomes the detrimental effects of tannins and suggests that the main effect of protein addition involves a complexing of tannin with the added protein. (4) Although tannins could not be detected in the blood of chicks fed HTS, the activity of an enzyme known to detoxify phenolic compounds (UDP-glucuronyl transferase) was higher in the livers of HTS-fed chicks as compared with those fed LTS, which suggests that tannins, or their monomers, are absorbed and enducing this enzyme system. (5) Approximately 500 slides of intestinal tissues (esophagus, duodenum and colon) from chicks and rats fed HTS and LTS have been prepared and are currently being evaluated for possible histological anomalies caused by tannins.

INTSORMIL - COORDINATED RESEARCH SUPPORT PROGRAM - GRAIN SORGHUM/PEARL MILLET
Purdue University Project No. XII PRF5

Project Name: Pricing, Policy and International Trade Constraints on Sorghum and Millet Production and Utilization in Developing Countries

Personnel: Robert L. Thompson, Philip C. Abbott, Associate Professors; David Bieber and Michael Roth, Graduate Students

Overseas Linkages: Thompson participated in INTSORMIL team visit to the Philippines (March 1981). Discussions are in progress with IFPRI/ICRISAT/IRAT to collaborate on their proposed project on "The Economics of Coarse Grains in Millet/Sorghum Areas of West Africa: Case Studies and Policy Issues." The Purdue Agricultural Economics Dept. is involved in development assistance projects in Upper Volta, Niger and the Ivory Coast, through which linkages exist to researchers in those countries. Abbott and Bieber will go to Upper Volta, Niger and Ivory Coast to collect data and establish more direct linkages as soon as approvals are received. Thompson plans an African trip with similar objectives in May-June 1982; Roth plans to collect dissertation data overseas if an appropriate situation can be identified beginning in mid- to late-1982.

Major Objectives: In selected low income countries where sorghum and millet production are important: (1) To document and describe recent trends in the role of sorghum and millet in cereals production, consumption, and trade and to relate changes in imports of various cereals to changes in sorghum and millet production and consumption; (2) Evaluate the technical and socio-economic substitution possibilities among cereals in both production and consumption to provide a basis for evaluating the effects of policy-induced price distortions; (3) To update documentation of the aid, trade and domestic policies and employ effective rates of protection and sector modeling to draw implications for sorghum and millet production and use and for adoption of improved technologies; (4) Through collaboration, to train developing country analysts to carry on this type of research, and, later in the project, in countries where in-depth analysis has been carried out, to work with government officials in designing more efficient means of attaining the same ends.

Significant Research Findings: This project, which began in mid-1981, has no definitive findings to report as yet. Progress on the various objectives is reported here. Most data needed to accomplish objective (1) has been assembled, and it is expected that this objective will be satisfied by the end of year 1. Review of relevant literature on sorghum/millet economics, including evidence on substitution possibilities and on West African agricultural policy analyses is in progress. Alternative conceptual frameworks for evaluating the effects of trade and agricultural policy, including food aid and food security strategies, on sorghum/millet production and consumption in West Africa are now being evaluated. Research to date indicates that several West African countries have adopted policies which serve as disincentives to sorghum and millet production and which heavily tax agriculture. If current trends continue, such policies could lead to disastrous outcomes in the future as the need for food imports increases if export earnings are stagnant. Food aid donated in the current policy environment may exacerbate these problems, as further disincentives to production and technological change are introduced.

Two thesis research topics are evolving within this context which will contribute to objective (3), and peripherally to objective (2). The first (Bieber's) will employ stochastic simulation to evaluate the effects of alternative price, storage, and import policies on sorghum/millet production and consumption, and hence on food security, for one or more West African countries. This will extend previous work by including the effects of on-farm storage and marketed surplus response, while recognizing that these crops are less than perfect substitutes for other cereals. The other thesis (Roth's), which is in the problem definition stage, will likely address long-run implications for technology adoption and growth in sorghum/millet production of current agricultural, trade and aid policies.

INTSORMIL PROJECT SUMMARY - 1981-82

PROJECT NO. TX-21

PROJECT NAME: Breeding for Productivity

PROJECT LEADER: F.R. MILLER

PROJECT PERSONNEL: W.J. JORDAN, P. MORGAN, and R. CREELMAN

Graduate students: N. Ochanda (Kenya), S. Da (U. Volta), A. Abdalla (Sudan), L. Traore (Mali), A. Valdes and P. Jasa (Mexico), H. Saadan (Tanzania), L. Smith (Texas), J. Mann (Colorado/Tanzania), J. Raab (Indianna), B. McIntyre (Canada), Anne Alegre (France), R. Monk (Texas), Y. Kebede (Ethiopia) and J. Pao (Tawian).

OVERSEAS LINKAGES: Positive interaction and cooperation has been established with co-workers in Mexico, Salvador, Honduras, Mali, U. Volta, Tanzania, Ethiopia, and ICRISAT. F_2 and other early germination breeding materials as well as trials of advanced hybrids and a broad array of experimental lines and hybrids possessing high yield capability and agronomic desirability were provided to programs in the above mentioned countries and others. A clearer understanding of which materials from among our elite lines that express high yield potentials in diverse environments is evolving. The 'Sorghum in the Eighties' meetings sponsored by ICRISAT-INTSORMIL was successful in demonstrating cooperation between breeders and food scientists. Breeding for specific characteristics identified from the International Food Quality Trials (IFQT) will reduce many errors in selection programs where the end product goes into traditional sorghum foods. The development and use of color prints describing major pericarp genes and their effects will permit breeders and food scientists all to relate to specific genotypes.

An INTSORMIL funded breeder was placed in Honduras to work on the incorporation of food quality and high productivity for that country and to spread breeding material throughout Latin America. Exchange of breeding materials from a country-to-country rolling selection program has begun. Over 3500 F_5 selections from Guatamala have been returned and 450 F_3 selections from Mexico will be evaluated in food quality, disease/insect and adaptation nurseries in Texas.

As soon as word came that additional zerazeras from Gambella had been collected by ICRISAT, Ethiopia and Sudan workers these important materials were obtained for conversion. Seventeen graduate students (12 international) have been strongly involved in the program with projects relating to sorghum productivity beneficial to the international situation. These people will likely be our greatest contribution to developing agriculture.

MAJOR OBJECTIVES:

1. Develop sorghums with wide adaptation and stable yields.
2. Determine effects of photoperiod and especially temperature on growth and development as related to productivity.
3. Determine the relationship between yield and photosynthetic activity.
4. Assessment and utilization of physiological measures of drought resistance to improve sorghum.

SIGNIFICANT RECENT FINDINGS: Sorghums possessing high potential have been identified from plantings across USA, Mexico, Latin America, South America and parts of Africa. Numbers of seeds/panicle are most sensitive to environmental stresses and only maximum stresses affect seed size. Selection for high numbers of kernels/panicle is extremely critical in local breeding programs. Tropically adapted (TA) types with high yield potential have proven superior in Mali, U. Volta, Sudan, Ethiopia, as well as Central and South America. Corrections in food quality characteristics and some disease properties remain. When hybrids go in Sudan ATx623, etc. will be the female used. The same is true for many

other tropical areas. White seeded, tan plant color breeding lines (>4000 selections) were selected from populations evaluated for tó quality. NaOH screening has shown that desirable tortilla color can be selected on plants possessing PPQQor PPqq. Using an elite food type population, combining critical disease screening locations, and the rolling selection process, a program of combining all these traits with high yield and adaptation in Texas (2 locations), Georgia, Puerto Rico, Honduras and Mexico has been developed and initiated. Germplasm previously identified as superior, zerazera (class 39-1), was collected in Gambella, Ethiopia and immediately put into the productivity breeding program (67 items). Materials from China (89 items) have been found to be extremely susceptible to downy mildew even though cold tolerant. Epicuticular wax (EW) loads increase in response to water stress. Lines with high or low EW across environments have been identified. Behavior of high and low EW in hybrid combination suggests genetic improvement in high EW. These materials behave similarily in Texas, Latin America and Mali. Lines with high heat (HT) or desiccation tolerance (DT) have been identified. Cultivar rankings for these two traits suggest these evaluations represent independent estimates of stress tolerance. Selections have been made based on HT and DT evaluations. Sorghums selected with base temperatures (BMT) above 10.5C perform well in the temperate zone and those below 10.5C BMT perform best in Mexico and South Texas. Hormone balance which affects leaf form, floral initiation date and yeild also makes plants early or essentially photoperiod insensitive. These same genes are affected by night temperatures. Post-flowering drought resistance in a nonsenescing (NS) line suggested consistently lower transpiration rate, stomatal conductance and leaf temperature (both senescent (S) and NS lines grown in same lysimeters). Leaf water potentials of NS line was higher (by 1-2 bars) under similar stress conditions. Stomatal conductance in NS line less readily reduced by leaf water potential losses suggesting involvement of osmotic adjustment. Longer leaf area duration and post flowering increases in stem sugar concentrations suggest greater photosynthetic gains in the NS line under similar conditions.

PROJECT NAME: Breeding for Disease and Drought Resistance and Increased Genetic Diversity PROJECT NUMBER: TAM-22

PROJECT LEADER: D. T. Rosenow

PERSONNEL: L. E. Clark, K. F. Schertz, Roberta H. Smith, C. W. Wendt (Investigators) C. A. Woodfin, A. J. Hamburger (Research Associates), Sharmalya Bhaskaryn (India) (Post Doc.), N. Ochanda (Kenya), (Grad. Student).

OVERSEAS LINKAGES:

Major collaborative efforts exist with Mexico (disease and drought), Honduras (disease), Sudan (drought and disease), Mali (drought) and Egypt (drought). These involve germplasm exchange, on site disease and/or drought evaluation, visits by INTSORMIL scientists with evaluation of material, and discussion and development of screening and selection techniques. Other countries where major shipments of sorghum germplasm was sent for evaluation and use include Niger (disease), Philippines (disease), Colombia (disease), Brazil (disease and drought), Venezuela (disease), Argentina, Mauritania (variety use), and Somalia (hybrid and variety use). INTSORMIL developed sorghums were identified with high levels of drought tolerance in Sudan. These, along with disease resistant types identified in several countries should contribute to the development of improved locally adopted sorghums through breeding. A cooperative study with ICRISAT has been started to identify parents for use with new cytoplasmic sterility systems. This will promote the development through breeding of more diverse and productive hybrids.

Rosenow served as team leader for the initial INTSORMIL visit to Mexico, which initiated the development of a Memorandum of Agreement with INIA which now lacks only a signature. He also was a member of the INTSORMIL team which in the Fall of 1981 resulted in two signed Memorandum of Agreements in Sudan. He worked on collaboration with breeders with primary emphasis on germplasm exchange and drought tolerance. This was followed up by a return visit in November, 1982, with a detailed look at INTSORMIL and Sudanese materials at four major sorghum nursery sites, and development of plans for future collaborative efforts on breeding and drought selection techniques. Rosenow also evaluated sorghum germplasm in Mali, participated in and presented papers at the Sorghum Disease Shortcourse for Latin American Workers at El Batan, Mexico, and presented papers at the Sorghum Grain Quality and Sorghum in the Eighties Symposia at Hyderabad, India.

MAJOR OBJECTIVES:

1) Screen and evaluate sorghum germplasm for disease resistance and drought tolerance.
2) Develop disease-resistant, high yielding cultivars with resistance to such diseases as downy mildew, grain mold (weathering), anthracnose, head blight, leaf blight, rust, zonate, charcoal rot, and viruses.
3) Develop through breeding and selection, agronomically desirable types with superior drought tolerance.
4) Identify cytoplasms that differ from milo in sterility response.
5) Using tissue culture techniques, select for variation in vitro for drought and nutrient tolerance.

SIGNIFICANT RECENT FINDINGS:

Several breeding and converted lines were identified in Puerto Rico as having excellent anthracnose and rust resistance. A random mated population developed cooperatively with Georgia and Puerto Rico is ready for release. This germplasm should be useful in areas of Central and South America where anthracnose is a serious disease. Large disease screening and breeding nurseries in Texas led to the identification in 1981 of new sources and breeding materials with resistance to downy mildew, head smut, grain mold (weathering), rust, zonate leaf spot, and grey leaf spot. Emphasis on selection was on tall, white seeded, food type sorghums for potential use in DC's. Trials elsewhere providing good data were Georgia (anthracnose and grain mold), Puerto Rico (anthracnose and rust), Philippines (grey leaf spot), Mexico (leaf blight, rust), and Mali (sooty stripe). A large amount of disease resistant and high yielding germplasm was planted in Honduras for evaluation later this Spring.

In Sudan, at Wad Medani and Gadambalia, lines and hybrids identified in Texas as being tolerant to post-flowering drought stress performed very well. The line SC35 and its hybrids were particularly outstanding. At El Obeid, under sandy soil and marginal moisture, several INTSORMIL developed lines showed outstanding promise. It appears that materials developed in our drought breeding program can have direct application in Sudan. Post flowering drought tolerance is an important trait in Mali, and U.S. developed germplasm with such tolerance should be useful there. In India, 13 U.S. developed charcoal rot (post-flowering drought tolerant) resistant lines showed excellent charcoal rot resistance under field evaluation.

The large field screening drought breeding program in West Texas identified several new converted sorghum lines with good drought tolerance. A large number of selections were made at Chillicothe, Halfway, Lubbock, and Big Spring in F_3 and F_4 breeding progeny involving pre- and post-flowering drought tolerant lines. Lines and hybrids of known stress reaction were evaluated under a line source sprinkler system at Chillicothe. The gradient provided good differential in yield and lodging response. Lines and hybrids known to possess good post-flowering drought response under field conditions exhibited no lodging whereas materials with post-flowering response lodged severely. Thus, the gradient appears well suited for evaluating for both pre- and post-flowering response, and should be useful as a selection tool for drought in U.S. as well as the DC's. A rainout shelter containing three replications of 77 lines provided severe moisture stress, with only 6 lines producing fertile heads. These 6 lines have shown excellent pre-flowering drought stress tolerance under field conditions. It appears that rainout shelters can be successfully used to screen for pre-flowering drought tolerance, and that up to 400 entries could be screened per shelter.

Excellent callus growth has been obtained on three genotypes grown on aluminum-containing medium ranging from 0-400 μM Al. These, as well as genotypes on NaCl selection medium have not yet been regenerated. Evaluation of invitro-derived lines for wax and heat tolerance has been completed but not yet analyzed. Twenty-four lines from the Sorghum Conversion Program have been identified that have cytoplasms that induce male sterility. Some of these differ from the cytoplasm that is used to nearly all hybrids and others are being tested, using F_1 sterility response and mitochondrial DNA analysis. A cooperative study was started with M. J. Vasudeva Rao, ICRISAT, to utilize these diverse cytoplasms in broadening genetic diversity.

PROJECT NAME: Breeding for Insect Resistance and Nutrient Use Efficiency PROJECT NO.: TAM-23

PROJECT LEADER: J. W. Johnson (D. T. Rosenow - Acting)

PERSONNEL: A. B. Onken (Investigator), J. Jones, V. Riggs (Technicians), M. Lavelle (Student Worker)

OVERSEAS LINKAGES: Collaboration with scientists in Egypt, Mexicc, and Honduras has resulted in significant technology transfer, and has led to sound cooperative associations. On a site visit to Egypt, the greenbug was identified to be the cause of severe damage to local sorghum varieties. As a result, greenbug as well as drought resistant sorghum lines were sent to Egypt and evaluation and breeding methodology were coordinated with Egyptian sorghum breeders. This should allow the incorporation of greenbug resistance into locally adapted and desired sorghum varieties. Sorghum midge resistant nurseries and specific tests were supplied to scientists in Mexico. Data from duplicate nurseries and tests from Texas are similar. Insect resistant sorghum lines were supplied to the Texas/INTSORMIL scientist stationed in Honduras and crosses to local varieties are being made. Insect resistant germplasm was also supplied to cooperators in Sudan, Mali, Uruguay, China, Argentina, Botswana, India, Venezuela, and Taiwan.

A. B. Onken served as team leader in the signing of a Memorandum of Agreement between INTSORMIL and the Institute of Rural Economy of the Malian Ministry of Agriculture for conducting joint research programs in cultural techniques, breeding, soils, agro-meteorology, and training. Linkages were also established with Dr. John Scheuring and Mr. Phil Serafini, ICRISAT, Mali. Fifteen Malian sorghum lines, four sorghum hybrids, and three millet lines are being screened for nutrient use efficiency at Lubbock. Profile soil samples from a Malian experiment station are being shipped to Texas for basic chemical and physical analyses. A neutron probe has been provided to Malian scientists for use in their drought research program. A technical training mission to Mali in the use of neutron probes has been completed.

MAJOR OBJECTIVES:

1) Obtain germplasm to be evaluated for resistance to arthropod pests.
2) Determine the inheritance of insect resistance.
3) Develop and release high yielding, agronomically improved sorghums resistant to selected insects, with emphasis on the sorghum midge and greenbug.
4) Identify and define potential sources of more efficient plant nutrient extraction and/or utilization in sorghum.
5) Develop agronomically elite sorghums with improved nutrient use efficiencies.
6) Develop new methods for determining nutrient use efficiencies and to study responsible mechanisms when appropriate.

SIGNIFICANT RECENT FINDINGS:

Grain sorghum germplasm with high levels of midge resistance derived from AF28 was released and distributed. F_1 hybrids involving parents with two sources of resistance, TAM2566 and AF28, had a higher level of resistance than either parent, indicating complementation of resistance when two different sources are combined. Tropically adapted female lines with high levels of midge resistance are needed, and some F_3 progeny rows showed excellent potential. Three new midge resistant B-lines and seven new midge resistant restorer lines were selected for release. These include lines derived from three new sources, SC237, SC414, and SC424. Midge ratings on all fully converted lines were published. Several commercial hybrids in the U. S. are using previously released midge resistant parental lines developed and released in this program.

SIGNIFICANT RECENT FINDINGS (CONTINUED):

In Egypt biotype C greenbug caused significant leaf damage, and biotype C resistant genotypes developed in the U. S. showed good resistance. In Texas, four lines, PI264453, PI220248, Capbam, and TAM Bk-42, were identified as having high levels of resistance to the new greenbug biotype E. Agronomically improved biotype E resistant selections were made in F_2 populations, which was the first cycle to produce tropically adapted, biotype E resistant lines. Biotype E resistance was determined to be a simply inherited dominant character. Ten new biotype C resistant lines (3 AB pairs, and 7 restorers) were selected for release.

Twenty-four elite breeding lines were screened in low N field plots for Nitrogen use efficiency. Five of these lines were identified as being significantly superior to two other lines. The superior lines were: SC630-11E, MR4(4606), R6956, Tx2536, and BTx623. Several of these have excellent potential in developing countries. The lines MR4(4606), R6956, and BTx623 are tropically adapted and have good yield potential as well as resistance to many diseases. The line SC630-11E has good weathering resistance and BTx623 is a widely adapted female that will be used to produce hybrids in DC's.

Twelve elite breeding lines were screened for P using efficiency (mg dry matter/mg P taken up) in nutrient solution culture in the greenhouse. Three lines were found to be significantly superior to two others. The superior lines were Tx2536, SC414-14, and SC175-14. Both SC414-14 and SC175-15 are widely adapted, possess midge resistance, and have good yield potential in the tropics. It is noteworthy that Tx2536, which is known to produce well adapted hybrids throughout much of the world, scored well in both N and P use efficiency tests. Previously reported research has indicated a possible inverse relationship between Fe and P use efficiencies. These same lines have been previously (1980) screened for Fe use efficiency and there appears to be no relationship between their ratings for Fe use efficiency and P use efficiency. An inverse relationship was found between P concentration in the leaf tissue and P use efficiency.

Four breeding lines were selected for high and low N use efficiency based on previous research and grown at four levels of N in nutrient solution culture in the greenhouse. Separation of genotypes for N use efficiency (mg dry matter/mg N taken up) was greatest at the lowest N rate. Concentration of N in leaf tissue was inversely proportional to the N use efficiency. Nitrogen use efficiency increased with decreasing N concentration in the nutrient solution.

PROJECT NAME: Sorghum and Millet Pathology PROJECT NO.: TX-24

PROJECT LEADER: R. A. Frederiksen

PERSONNEL: G. Odvody, J. Craig, R. Toler, L. Reyes (INVESTIGATORS); L. Castor, D. Tuleen, O. Ziv (POST DOCTORATES); G. Forbes, M. Howell, G. Wall (El Salvador), M. Natural (Philippines), L. Giorda (Argentina), (GRADUATE STUDENTS); D. Collins, P. Berger, C. Kempf (TECHNICIANS).

OVERSEAS LINKAGES: *Sorghum Diseases, A World Review*, a joint project of INTSORMIL/ICRISAT and Texas A&M University, served as the text for the Sorghum Disease Shortcourse for Latin American workers at El Bataan, Mexico. This shortcourse, given in Spanish, reviewed the etiology and control of all major Latin American diseases of sorghum. Field trips, disease diagnosis, disease ratings, and selected demonstrations were included. A proceedings in Spanish/English was prepared. The shortcourse involved most INTSORMIL pathologists and other specialists, and will serve as an important model for similar shortcourses. Another shortcourse, leading toward the development of a sorghum/millet disease management manual is planned for September 1983 In Upper Volta. INTSORMIL disease nurseries including the International Disease and Insect Nursery, Sorghum Downy Mildew Virulence Nursery, Downy Mildew Resistant Converted Line Test, Uniform Head Smut Nursery, Converted Line Anthracnose Test, International Sorghum Anthracnose Virulence Nursery, and International Sorghum Virus Nursery were grown cooperatively at key sites in Argentina, Brazil, Colombia, Egypt, France, India, Mexico, Philippines, Sudan, and Venezuela. A data logger for acquisition of remote weather data was placed at Ocotlan, Mexico in conjunction with collaborative studies on disease progress and yield losses. A major collaborative project with Sudan was established and evaluated after 1 year of operation. Sorghum pathology and breeding projects in Egypt were reviewed in depth. Several LDC scientists, students and research staff received training in procedures for working with sorghum downy mildew.

PROJECT OBJECTIVES:

1.) Identify, catalogue, and evaluate sources of disease resistance in sorghum and millet.
2.) Develop effective screening techniques for detection and incorporation by breeding of superior plant resistance levels.
3.) Study disease etiology or factors associated with the cause of plant disease.
4.) Explore the use of cultural, chemical, and biological control measures as an adjunct to control by disease resistance.
5.) To collect and evaluate populations of plant viruses for their range or changes in virulence and to develop disease diagnostic systems.
6.) Determine mechanisms of disease resistance.

SIGNIFICANT RECENT FINDINGS: Naturally occuriing disease epidemics permitted the identification of several sorghums with high levels of resistance to grey leaf spot, sorghum downy mildew (SDM), head smut and grain mold. A local lesion screening technique will permit evaluation of resistance of individual plants to downy mildew in 7 days, as compared with 21. The SDM pathotype at Moluco, Mexico appears to be pathotype 1, but pathotype 3 has been found at 2 locations in Texas. Resistance to SDM in sorghum remains as a program of mutual interest with ICRISAT. Techniques were developed for obtaining spores of *Cercospora sorghi*, permitting the management of grey leaf spot under more controlled conditions. Acremonium wilt in the U. S. is similar to the wilt of sorghum described in Egypt.

Under a three-year simulated crop rotation system soil-borne (oospores) and SDM incidence declined to levels significantly less than those obtained under susceptible sorghum monoculture. Deep plowing (30 cm) reduced oospore populations in the SDM-critical area of the soil profile (15 cm) and significantly reduced SDM incidence the

following season.

The systemic fungicide metalaxyl gave complete control of SDM when utilized as a seed treatment and was an effective eradicant of SDM in systemically infected sorghum plants when utilized as a foliar applicant.

A standardized charcoal stalk rot screening technique for use in germplasm evaluation is being developed which will provide for more predictable, more natural, soil-mediated charcoal root and stalk rot development. At mid-season, sorghum plants from seed treated with a bacterial protectant had significantly less root infection and damage caused by *Pythium graminicola* than plants from nontreated seed but at harvest there were no differences between treatments.

Antisera to Panicum mosaic virus and maize dwarf mosaic virus (MDMV) strains D, E, F, and B were produced in quantities sufficient to supply other countries. Antisera are being used in Mexico to aid in the identification of unknown viral pathogens in the nursery. A new virulent virus obtained from sorghum is being described. Biotype E of *Schizaphis graminum* was an effective vector of MDMV and has an extended virus retention period.

Collaborative work in Egypt has led to the discovery of both an inoculation technique for evaluating sorghums for resistance to long smut and the identification of a few resistant converted sorghums. Equally important has been the identity of unusually susceptible germplasm.

INTSORMIL PROJECT SUMMARY

PROJECT NAME: Sorghum Entomology PROJECT NUMBER: TAM 25

Project Leader: George L. Teetes PERSONNEL: F. E. Gilstrap (Co-investigator), P. S. Menefee (tech.), F. R. Baxendale, K. D. Melton, G. J. Hallman, D. G. Hall, C. L. Lippincott, J. Waquil (Brazil), A. Jalil (FOD.-Bangladesh), T. J. Kring, G. W. Brooks, R. W. Jones

OVERSEAS LINKAGES: Collaboration with scientists in Mexico, Honduras, Costa Rica, Brazil, Kenya, Senegal, Mali, Sri Lanka, India, and ICRISAT has been effective and mutually beneficial. Research is on-going in Mexico with Jesus Vargas where duplicate experiments are conducted on sorghum midge, and results agree with that obtained in Texas. Teetes served as team leader of a site visit team to Honduras that resulted in signed collaborative agreements and the stationing of an M.S. graduate student advised by Gilstrap to evaluate Doru taeniatum as a predator of fall armyworm at the Escuela Agricola Panamericana, and the stationing of a Texas A&M breeder/agronomist at the La Lujosa Exp. Sta. Gilstrap sent a parasite of Chilo sp. stem borers in Pakistan to the Costa Rican Min. of Ag. for release against the sugarcane borer. Continued collaboration with Brazilian scientists has resulted in graduate student training and joint development of midge resistant sorghums. Collaborative research on borer pests of sorghum has been activated with Seshu Reddy of ICRISAT in Kenya (ICIPE) and Teetes will be a participant in a workshop on "Bases of Plant Resistance and Crop Borers" in Sept., 1982 in Kenya. Gilstrap is major advisor to O. Youm, an M.S. student from Senegal studying parasitism of aphids, and returning to Senegal in 1984 with the US/Senegal program of biological control of aphids. Gilstrap obtained identification for two species of parasites attacking Acigona sp. stem borer for Mali scientists. Gilstrap is major advisor to B. Dayawathie, a Ph.D. student now in Sri Lanka conducting her research on "Life Table Analyses to Evaluate Parasites of the Rice Stem Borer, Tryporyza incortulas. An on-site consultation was made in Oct. 1981. A handbook on sorghum insect identification is in the printing stage, is a joint effort of INTSORMIL, ICRISAT and TAES, and contains colored pictures of pests and their damage, descriptions, biology and control measures and will be printed in English, French, and Spanish. Grilstrap collected phytoseiid predators attacking spider mites of sorghum/millet in India for identification, which will serve as the basis for exchange of mite predators between India and Texas. Texas entomologists participated and presented papers at the Sorghum in the 80's Symposium in Hyderbad in Nov., 1981. Requests for publications and methodology were received and sent to 27 scientists in six LDC's. An International Sorghum Insect Workshop is planned for March, 1983 sponsored by INTSORMIL, ICRISAT and the Rockefeller Foundation. Negotiations are underway for graduate training of students from Sudan.

MAJOR OBJECTIVES: (1) To identify and evaluate sorghums resistant to insects, determine resistance mechanisms, investigate plant-pest ecological responses and determine economic injury levels.
(2) To identify and evaluate indigenous and/or exotic natural enemies of sorghum midge, aphids, mites, and several lepidopterous pest species as potential biological control agents.
(3) To determine the biology, systematics, behavior and abundance of sorghum insect pests and associated predators and parasites as support of pest control schemes for adaptation to LDC conditions.

SIGNIFICANT RECENT FINDINGS: Sorghum midge resistant sorghums have the same level of resistance in all countries where the material has been evaluated as they do in Texas where they were developed, but must be adapted to local conditions, esp. diseases, panicle bugs, other pests and conditions. Several seed companies are using midge resistant lines developed in Texas for hybrids to be sold in 1982. Lines developed from AF-28 discovered in Brazil, synergizes the resistance from TAM 2566 discovered in Texas, in hybrid combination. The economic threshold of midge resistant hybrids is at least five adults/panicle compared to one for susceptible hybrids. Midge resistance is multiple, minor gene resistance, influenced by environmental and midge density, but should be stable against biotypes. Midge produce 50% fewer progeny from resistant than susceptible hybrids up to an unidentified density threshold. Moisture, and/or high RH, moderate temperatures (80-90°F), day light and host availability favor midge diapause termination and increased abundance. These data can be used to explain regional and temporal severity of midge and is being used to develop a computerized, biophysical model to simulate midge population dynamics for predictive purpose and will have utility in explaining why the midge reaches damaging proportions in some areas of the world. Four species of midge parasites were identified and their biology and nature of parasitism determined. Midge parasite dynamics on *Sorghum halepanse* are significantly different from those on commercial sorghum. Economic thresholds of panicle feeding bugs were developed and the methodology used has direct application to the recent increase in panicle bug damage to tight-headed sorghums in India and Africa.

A greenbug biotype change was confirmed and lines resistant to biotype C and E were evaluated. Greenbug resistant sorghums are susceptible to shoot fly and stem borers in India. Seed of "glossy" sorghums resistant to shoot fly are being sent from ICRISAT for screening against aphids. Four lines from Texas were resistant to the sugarcane aphid in Taiwan and seed of these and others have been sent to China. Greenbug on wheat, the winter host of the sorghum greenbug experienced a low level of parasitism throughout the duration of infestation, and hyperparasitism did not appear to limit primary parasite population growth. Parasitism distribution is not aggregated within the aphid population, but the aphid population is significantly aggregated within the field. A significant level of emigration by immature greenbug parasite stages via emigration of winged aphid hosts was shown to occur and suggests that proper evaluation of parasite induced mortality must incorporate aphid dissections. At least three species of phytoseiid predators of spider mites occur naturally in a sorghum/corn ecosystem and are tolerant to selected pesticides.

Research results summarized here have been or are being published. Most research involves graduate student training programs at the M.S. and Ph.D. level.

INTSORMIL PROJECT SUMMARY Jan. 15, 1982

PROJECT NAME: Food Quality and Nutrition PROJECT NO: TAM 26

PROJECT LEADER: Dr. L. W. Rooney, Professor

PROJECT PERSONNEL: Dr. J. M. Faubion, Asst. Professor, Dr. M. Morad, Research Associate

GRADUATE STUDENTS: J. O. Akingbala, Nigeria; S. Bedolla, Mexico; Ms. C. Doherty, U.S.A.; S. S. Da, Upper Volta; Ms. C. Choto, El Salvador; Ms. P. Wongvorazathe, Thailand; Mr. Sadaan, Tanzania; Mr. D. Hahn, U.S.A.; Mr. R. Pflugfelder, U.S.A.

OVERSEAS LINKAGES:

Collaboration with personnel in Mali, Upper Volta, Mexico and ICRISAT has been productive. The first International Symposium on Sorghum Grain Quality was held at ICRISAT in Hyderabad, India in October, 1981. The conference sponsored by ICRISAT-INTSORMIL was successful in part because of the International Food Quality Trials (IFQT) which were conducted in 1979 and 1980. A clearer understanding of the wide variety of traditional sorghum foods and how to determine the essential quality characteristics of basic foods emerged. Rooney traveled three times to ICRISAT (India) to review data from the IFQT, plan the quality Symposium and coedit the proceedings with D. S. Murty (ICRISAT).

A sorghum food quality workshop for Central American workers sponsored by INIA, ICRISAT/CIMMYT and INTSORMIL to be held at CIMMYT in Spring of 1982 is being finalized. The emphasis will be on potential of sorghum for tortillas. A guideline for selecting for tortilla quality in a breeding program coauthored with Drs. A. Ireugas, INIA and V. Guiragossian, ICRISAT/CIMMYT was presented at the PCCMCA meeting in the Dominican Republic. A set of slides illustrating kernel characteristics and other selection indexes has been developed. As part of the collaborative research physical, microscopic, milling and cooking trials have been run on grain samples from Mali, Upper Volta, Mexico and India.

We found that Tô quality could be measured with a penetrometer. Scheuring (Mali) has used our early findings to devise a mini-procedure for predicting Tô quality. Milling and microscopic studies in our laboratory at Texas A&M have confirmed field trials conducted in Mali that show sorghums with a thick pericarp are most easily milled by hand pounding. Mr. S. S. Da, Graduate Student - Upper Volta, outlined how to measure Tô quality in a breeding program in the Sorghum Quality Symposium in India. He will be returning to Upper Volta to apply these procedures in a breeding program. Graduate Students are a major way of establishing worthwhile cooperative efforts that can have long term impact when they return home.

MAJOR OBJECTIVES:

1. Determine how sorghums are processed, prepared and consumed in traditional village foods and determine the grain characteristics that affect the organoleptic properties of the traditional food products.
2. Develop simple, practical laboratory methods for use in breeding programs to assess important grain quality characteristics.
3. Determine physical, chemical and structural factors that affect the food and nutritional quality of sorghum and seek ways of modifying the properties or improving methods of processing.
4. Determine the factors that affect resistance to grain molds and field deterioration in sorghum and devise laboratory procedures to detect genotypes with resistance.

SIGNIFICANT RESEARCH FINDINGS:

Lab procedures for Tô and tortilla production have been standardized. Selection in the field based on visual kernel characteristics is an effective, simple way of selecting for sorghum quality in preliminary trials. The genetics of

kernel characteristics of sorghum have been illustrated with color slides and photomicrographs. Milling properties can be determined by milling 10 g of sorghum in a small laboratory mill. Then, the decorticated grain can be used for the micro Tô tests for measurement of Tô texture (softness) and stickyness. Amylose content and some gel consistency tests were not highly correlated with Tô texture and acceptability. The gelatinization temperature and specifc heat of sorghum starches from the IFQT were not related to food quality. Rheological properties, ie viscosity, may be related to Tô quality. Particle size, variety, environment, pH and storage conditions affect Tô properties. A significant variety by pH interaction occurs. A variety that produces excellent acid Tô may produce poor quality alkali Tô. Local varieties are generally tolerant to pH changes.

Sorghum can be used to produce acceptable tortillas. Commercial and traditional procedures for preparation of maize tortillas in Mexico were documented. Sorghum requires less alkali, shorter cooking and steeping times than maize. Dry matter losses during optimum cooking and steeping of maize and sorghum are similar. The cooking time of sorghum varieties varies depending upon kernel texture (related to hardness), water absorption and other unidentified factors. Floury sorghums require less cooking time while cornous sorghums require the most.

An alkali test has been developed and used to select white kernels of sorghum with the least color. Several kernels of sorghum are boiled or heated in alkali and the color of the kernel and solution is subjectively rated on a 1-4 basis in comparison with standard samples. It is simple and can be modified for use in programs without laboratories.

The combination of better sorghum varieties with simple processing techniques to improve sorghum and sorghum-maize tortillas could lead to a better acceptance of sorghum as human food in Central America. Blends of masa from commercial white sorghums and white maize produced acceptable tortillas up to 40% sorghum - 60% maize ratios. When yellow maize is the standard, much higher levels of sorghum can be incorporated. These findings have been documented by Dr. Ireugas, INIA, Mexico. Sorghums that have been pearled to remove the pericarp can be made into high quality tortillas that compare with white maize. Even commercial U.S. red sorghum hybrids produce tortillas of edible quality when they are pearled to remove the colored pericarp. Blends of pearled sorghum and maize produce highly acceptable tortillas. Ground, micronized pearled sorghum has been used as a substitute and in blends with MASECA (an instant dry masa). Up to 30% of ground micronized sorghum (from a commercial red sorghum hybrid) was acceptable. Larger quantities of a white sorghum could be used.

Phytin complexes with minerals i.e. Ca and P. in cereals. Phytin content of sorghum was similar to that of other cereals and was located in the pericarp and aleurone layer. Levels of phytate phosphorous ranged from 0.17 to 0.38% (d.w.b.) accounting for 80-87% of total phosphorous present in 30 sorghum samples. The effect of processing sorghum on nutritional value was determined by using "in vitro" protein and starch digestibility procedures along with analyses for total phosphorous, total phytate phosphorous (phytin), iron, zinc, calcium and tannins. The effect of acid, alkali and neutral processing conditions on nutritional value of Tô produced from four sorghum varieties was significant. All processing conditions increased "in vitro" protein and starch digestibilities of the cooked freeze-dried Tô over that of the flour. Acid (lemon juice) cooking conditions increased the calcium content, reduced phytate phosphorous content and produced lighter colored Tô. Alkali processing increased ash content of the sorghum and caused undesirable color changes especially for sorghums with a testa or red pericarp.

The low molecular weight phenols of sorghums without a testa with varying degrees of mold resistance were determined by H.P.L.C. The quantity of free phenols was highest for sorghums with resistance to molds while more susceptible varieties had higher levels of bound phenols. Ten µm or more of Ferulic, gallic P-hydroxybenzoic and P-coumaric acid in the media inhibited hyphal growth of fungal isolates. These studies continue and phenolic acids will be related to nutritional value as well as mold resistance.

FORMAT FOR INTSORMIL PROJECT SUMMARIES

Project Name:

Project Number: XII TAM 31

Personnel: Dr. Dan H. Meckenstock

Overseas linkages: Ministry of Natural Resources
La Lujosa Experiment Station
Choluteca, Honduras

Counter Part:
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de Sorgo

Major objectives:

1. Establish a physical support base for INTSORMIL in Honduras.

2. Conduct cooperative research for INTSORMIL in Honduras.

3. Rejuvenate the Honduran Sorghum breeding project by
   a. Training local scientists.
   b. Developing disease resistant varieties with tortilla quality.
   c. Transfer hybrid production technology from U.S.

Significant recent findings:

1. Physical support base was established at the La Lujosa Experiment Station, in Choluteca, Honduras. Approximately 70% of my effort goes into restoring La Lujosa, and 30% into sorghum nurseries.
2. ADIN, TAT, ISVA, and ISAVN nurseries were planted December 3rd, in La Lujosa. The ADIN was also planted in Comayagua (Oct 6), Juticalpa, and Danli (Oct 27).
3. I am training two technicians and we are about to complete our first cycle. We were able to make some crosses with the local varieties and downy mildew resistant lines from TAMU. Some TA hybrids were planted as demonstration plots, but it is too early to evaluate them. More experimental hybrids from TAMU will be introduced for evaluation.