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INTSORMIL CRSP

EXTERNAL EVALUATION REVIEW

LUBBOCK, TX

September 15-19, 1980

FOREWORD

Earl R. Leng

Program Director, INTSORMIL

A central organizational feature of the Collaborative Research Support Programs (CRSP) is the requirement for periodic review by qualified and experienced individuals not connected in any way with the ongoing program. The Sorghum/Millet CRSP, launched in August 1979, had its first such review in Lubbock, Texas, the working week of September 15-19, 1980. The documents appended herewith are basic materials relating to this review, being the schedule of events, the roster of attendance, and brief summaries of each project being funded under the program.

Also included is a condensed statement of the linkage structures planned under the program. Most of these structures, except those relating to coordination among the participating Land-Grant institutions, are not yet in place. However, many of the plans are reasonably well advanced and another year is likely to see the majority of the linkages in operation.

INTSORMIL was fortunate in securing as the External Evaluation Panel the following individuals, each with extensive experience in international agricultural development. This panel is expected to be a continuing body, which will review major aspects of the CRSP at approximately yearly intervals. In this first review, the overall program and each authorized component project were reviewed.

External Evaluation Panel

Hugh Doggett (British) - IDRC, Sri Lanka
Brhane Gebrekidan (Ethiopia) - Ethiopian National Research Program
Bruce Maunder (U.S.) - DeKalb AgResearch, U.S.
Bobby Renfro (U.S.) - Rockefeller Foundation, Thailand
Uma Lele (India) - World Bank, Washington, D.C.
(Dr. Lele was unable to attend the review)

INTSORMIL LINKAGES

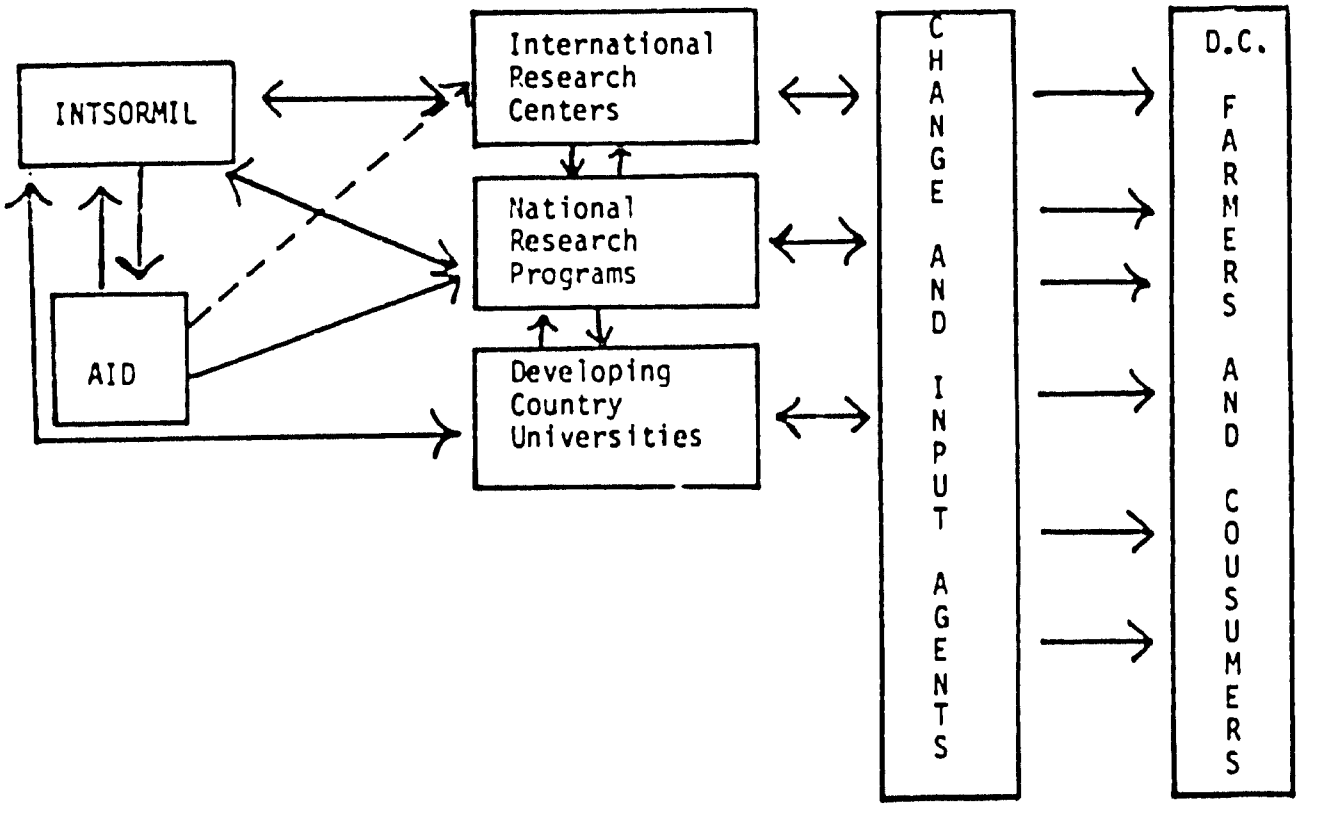
Earl R. Leng
Program Director

INTSORMIL linkages may be defined as internal and external. At present, the internal linkages are firmly in place; the external linkages are in various stages of development.

Internal linkages basically are interdisciplinary (both within and between participating institutions) and interinstitutional (both within and between discipli Some of these linkages are of long standing; others are extremely new and correspondingly fragile. In this latter class may be mentioned particularly a series of newly-formed ties between production-oriented biological research and consumer-oriented utilization and socioeconomic studies.

External linkages include those with AID, the principal funding agency, International Agricultural Research Centers, and developing-country agricultural researcl agencies and scientists. The latter group will become by all odds the cornerstone of the CRSP linkages. At present, few formal arrangements have been made with the developing countries but intense efforts are underway to develop such arrangements promptly.

International research centers form a convenient primary linkage base for CRSP work in developing countries. The chart following is a possible visualization of the CRSP position in overall development linkages, and accurately illustrates the relationship to ICRISAT and other international centers planned for INTSORMIL:



In this model, INTSORMIL will interact almost entirely with national research programs and international centers, and to some extent with developing-country universities. Its mission will primarily be technology development, with training as a secondary goal. It will attempt no direct intervention in the development process at the farm or consumer level, and little directly with the principal change agents.

Organization of developing-country linkages likely will take several forms. The ultimate goal is the closest possible tie of

INTSORMIL researcher to developing-country researcher

However, to achieve this, a variety of institutional arrangements may be utilized. These will include:

1. U.S. Institution to developing-country institution.
2. INTSORMIL to International Center.
3. INTSORMIL program-wide to developing country coordinated programs.
4. Complex networks involving combinations of the above.

Planned major locations for program-wide networks include the following countries:

ASIA

India (with ICRISAT)
Philippines)(with IRRI)
Indonesia)

AFRICA

Sudan (with SAFGRAD, ICRISAT and CID)
Mali (with SAFGRAD and ICRISAT)

NEAR EAST

Egypt (with CID)
Yemen (with CID and FAO)

LATIN AMERICA (with ICRISAT)

Guatemala)
Honduras) (Coordinated)
Mexico)

(A possible program with Brazil also is under consideration.)

The current status of linkage development is indicated by the following time/function table:

COUNTRY	VISIT	TEAM VISIT	ACTIVITY
India	10/79	?	----
Philippines	----	----	----
Indonesia	----	----	----
Sudan	10/79	planned 11/80	----
Mali	12/79	----	Technical Assistance*
Upper Volta	12/79		Technical Assistance*
Tanzania	10/79	6/80	Technical Assistance
Egypt	10/79	10/80	----
Yemen	10/79	----	Yes
Honduras	planned	10/80	----
Guatemala	8/80	planned 11/80	Yes
Mexico	8/80,9/80	planned 11/80	Yes
Brazil	----	----	----
Haiti	planned	10/80	----

* visit by Rooney and Kurleis at request of mission

** visit by Jackson

INTSORMIL REVIEW-SICNA MEETING AGENDA

Lubbock, Texas
September 14-19, 1980

SUNDAY, SEPTEMBER 14		
6:00-10:00 p.m.	Registration - Civic Center Inn 1202 Main (Main & Ave. K)	
MONDAY, SEPTEMBER 15		**CHAIRMAN**
8:00 a.m.	Registration - Texas A&M University Agricultural Research & Extension Center (Bus loads at 7:45 a.m.)	
8:30 a.m.	Welcome & Introductions - Conference Room - Texas A&M University Agricultural Research & Extension Center	
9:00 a.m.	Field Tour	
12:00 Noon	Lunch - Steak Barn	
1:15 p.m.	Field Tour (continued)	
3:00 p.m.	Depart for DeKalb Ag. Research Inc.	
3:30 p.m.	Field Tour - DeKalb	
5:30 p.m.	Bus returns to Civic Center Inn	
6:00 p.m.	Dinner - On your own	
8:00 p.m.	General SICNA Meeting Memorial Civic Center - Room 107	Jerry D. Eastin
9:00 p.m.	Individual SICNA Committee meetings - MCC Rooms to be announced	
TUESDAY, SEPTEMBER 16		
8:00-8:45 a.m.	Late Registration - Civic Center Inn	
9:00 a.m. (10:15 coffee)	Opening General Session - MCC 107 Board of Directors, Woods Thomas Program Director, Earl Leng Evaluation Committee Introduction ICRISAT Representative SAFGRAD Representative, Robert Gray Technical Committee - Program Details, Jerry Eastin	Jerry D. Eastin
12:00 Noon	Lunch - On your own	
1:30 p.m. (3:15 coffee)	* Breeding & Genetics Review - MCC 107	F. R. Miller
5:00 p.m.	Dinner - On your own	
7:00 p.m.	SICNA Discipline Reports - General Session - MCC 107	Jerry D. Eastin
8:00 p.m.	** Public Forum - Breeding & Genetics - MCC 107	F. R. Miller

WEDNESDAY, SEPTEMBER 17		CHAIRMAN
8:00 a.m.	Entomology Review - MCC 104-105	G. L. Teetes
(10:00 coffee)		
10:15 a.m.	Pathology Review - MCC 104-105	R. A. Frederiksen
12:00 Noon	Lunch - On your own	
1:30 p.m.	Physiology, Plant Nutrition and Cultural Practices Review - MCC 104-105	M. D. Clegg
5:00 p.m.	Dinner - On your own	
7:30 p.m.	Public Forum - Entomology - MCC 104-105	G. L. Teetes
8:30 p.m.	Public Forum - Pathology - MCC 104-105	R. A. Frederiksen
THURSDAY, SEPTEMBER 18		
8:00 a.m.	Quality & Nutrition Review - MCC 108-109	L. W. Rooney
(10:00 coffee)		
10:15 a.m.	Socio-Economics Review - MCC 108-109	L. Busch
12:00 Noon	Lunch - On your own	
1:30 p.m.	International Networks - MCC 108-109	Earl Leng
(2:45 coffee)		
3:00 p.m.	Public Forum - Quality & Nutrition MCC 108-109	L. W. Rooney
3:00 p.m.	INTSORMIL Board of Directors Meeting Room to be announced	
3:00 p.m.	Evaluation Committee Report Preparation (Private)	
5:00 p.m.	Dinner - On your own	
7:00 p.m.	Public Forum - Physiology, Plant Nutrition and Cultural Practices - MCC 108-109	M. D. Clegg
9:00 p.m.	Discipline Planning Meetings Rooms to be announced	
FRIDAY, SEPTEMBER 19		
9:00-11:30 a.m.	General Session Civic Center Inn Room "A"	Woods Thomas
9:00 a.m.	Evaluation Committee Report	
11:00 a.m.	Wrap up - Earl Leng	
11:30 a.m.	Adjourn	

* The review sessions are open to all, but on a non-participation basis except for the Evaluation Panel.

** Public forums are for participation, discussions, and presentations by participants, including non-INTSORMIL investigators. Each session will be organized by the respective INTSORMIL discipline coordinator.

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INTSORMIL

External Review and Planning Meeting

Lubbock, Texas

Institution: University of Arizona Project No. XII UA1

Project Title: Evaluation and Development of Sorghum Germplasm for Arid Land Agriculture.

Project Leader and Investigators: V. Marcarian, A. K. Dobrenz, R. L. Voigt, O. J. Webster.

Project 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 temperatures.
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.
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.

Research:

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, Arizona. Soils are sandy and low in fertility; rainfall averages 15.0 cm annually with virtually no rainfall during the growing season. Two hundred and seventy-seven different sorghum/millet lines excluding 77 checks were obtained from collaborating U.S. institutions and screened for drouth tolerance. Physiological and morphological data are being analyzed.

At the Plant Materials Center, Tucson, Arizona both drouth and non-drouth tolerant germplasm are being closer evaluated for mechanism of tolerance. Data have been collected for physiological characteristics, stomate density, leaf area index, photosynthesis, transpiration, leaf respiration, leaf temperature soil moisture extraction pattern, water potentials and specific leaf weight under low and high irrigation levels.

Lines performing best in the "low" and zero portions of the gradient system will be further selected and recombined for additional selection under moisture stress and high temperatures.

Twenty sorghum genotypes (Ten tested as tolerant and ten as intolerant of drouth stress under irrigation gra' _it in 1979) plus 2 controls with similar maturities of 74 to 77 days to 50 percent bloom in 1979 are being tested for yield and related physiological characteristics at Marana, Arizona. The genotypes
the irrigation gradient system in 1980 and the results correlated with 1979. They

being tested for actual yield under dry and irrigated field conditions and will also be evaluated in the laboratory for salt tolerance in the germination stage of growth.

Another genetic male sterile facilitated recurrent selection cycle of a drouth tolerant population is being grown under natural arid field conditions for further genetic recombination. Pollinated sterile heads are being selected for F_1 seed and fertile heads will be selected for further head to row testing under arid field conditions. A number of head-row plots are being grown and evaluated under arid field conditions. As many new potential drouth tolerant genotypes selections as space permits will be evaluated under the irrigation gradient system in 1981.

Graduate Student Training:

Personnel include: Peter Bourque, a former Peace Corps Volunteer - Ivory Coast, who is working for a M.S. with Dr. Voigt; Wally Hofmann, a former Peace Corps Volunteer - Togo, who is working with Dr. Dobrenz for a Ph.D.; Michael O'Neill, a former Peace Corps Volunteer - Upper Volta and Ghana, who is funded from sources other than Sorghum/Millet Title XII project, is working on the irrigation gradient and David Robinson, Research Assistant for Dr. Marcarian, is partially funded by the project. He served as Research Assistant in Yemen to Dr. Voigt. Sylvester Boye-Goni from Ghana is working with Dr. Marcarian on breeding of drouth tolerant and aluminium tolerant sorghum.

Summary of Significant Findings:

Preliminary screening of sorghum germplasm indicates variability among germplasm evaluated for drouth tolerance. See 1980 Preliminary Research Report.

Special Problems Encountered:

Yield data may be difficult to obtain due to bird damage--this may be overcome by using chemical repellants. Reduction of original budget from 100 to 60 percent placed a strain on in-state and overseas travel allowance and wages. We appreciate flexibility in redistributing funds between categories this first year so that our field operations in Yuma, Arizona were covered by necessary funding. Budget constraints at present will affect direct inernational involvement.

Proposed International Linkages:

Yemen - Contact has been made with Dr. D. Markarian, Chief-of-Party for the U of A AID Sorghum Improvement Project. Drouth tolerant sorghum germplasm will be submitted for verification in Yemen when research facilities are available.

ICRISAT - Dr. N. Seetharma and Dr. Scheering have been contacted for future consideration in evaluating drouth tolerant germplasm in their screening nurseries.

Senegal - Contact has been made with ISRA by Dr. Marcarian for possibility of conducting intercropping studies with millet as part of Bean/Cowpea Title XII CRSP.

Somalia - Contact made by Dr. Dobrenz with Dr. M. A. Wur, Vice Minister of Agriculture. They have expressed interest in colaborative research.

DEVELOPMENT AND LDC FIELD TESTING OF CULTURALLY ACCEPTABLE RECIPES UTILIZING GRAIN SORGHUM/PEARL MILLET (GS/PM).

Florida A&M University
Tallahassee, Florida.

Overview of Project

". . . if human food is a primary objective in the production of GS/PM, then the development and retention of acceptable taste in any new varieties through breeding programs must be given the highest priority . . ." Florida A&M University utilized the above quotation by the interim report of GS/PM by the University of Missouri working group to develop its project. Methods used by other studies in the developing countries where nutritional improvement of populations have been achieved through improvement of dietary habits and introduction of new recipes utilizing exising food grown in the country, were those chosen for this study.

The specific method undertaken by this study is stated as that of (i) the identification of existing food habits and current attitudes and beliefs about food of a selected sample of the population of the Republic of Haiti; (ii) the detailed analysis of the factors behind these habits, attitudes and beliefs; (iii) the design of a data base for the production of recipes produced from the new breed of GS/PM, with acceptable taste; and (iv) the design and execution of non-formal educational programs aimed at helping the population to imrpvoe their skill in food preparation as well as their related knowledge of nutrition.

Research Approach

(i) Establish linkages with institutions and/or organizations who may help to facilitate objectives of the project; (ii) design and pre-test an instrument for identification of food habits, beliefs and attitudes if the literature suggests this approach; (iii) execute a food habit survey on a representative sample of the population; (iv) critically analyze the instrument and develop a data base; (v) develop and test low cost nutritious recipes incorporating GS/PM, for acceptable taste and other palatability factors; (vi) develop country research capacity with particular emphasis on adapting research efforts to the needs of homemakers (vii) design and execute non-formal education programs to improve women's skills in food preparation and their knowledge of nutrition.

Results and Projected Efforts

Several linkages have been established as follows:

1. Mississipi State through Dr. Futrell, an international expert on this type of study.

2. The Haitian/American Community Association of Date County (HACAD), Miami. This organization is in close contact with the thousands of Haitians who have recently arrived on the shores of Miami. A preliminary survey carried out on a random sample of this population revealed the following information: (1) GS/PM is not extensively used in the northern sections of Haiti. There are clusters where extensive use of the grain is found. Les Caix seems to be a village where this project could carry out its first series of research methods, as it is not too far from Port-au-Prince, the capital city, and there is widespread use of the grain; (2) these grains are not easily available in Miami, but the population sampled would be happy to help with preparation of recipes - if it would help their people back home; (3) the main method of preparation appears to be 'mixed with beans and seasoned' or prepared in a similar way as rice and beans is by Black Americans; (4) the grain is not currently used as an infant feed. This is an area that has potential for research purposes.

3. Among the other organizations with whom linkage has been established and will be further strengthened are (i) CARE; (ii) Helen Keller International Inc. - who supplied us with documentation about their latest dietary/ nutritional work in Haiti; (iii) Church World Service.

4. Ms. Linda Morse, Public Health Advisor of USAID-Haiti, through whom contact with the Nutrition Bureau and the University of Haiti will be established. Ms. Morse has indicated that analysis of the dietary component of the 1978 National Nutrition Survey is in draft form, but will be made available for perusal on the project director's first trip to Haiti.

5. Dr. Lynn Coultas, a former colleague from FAMU, has resigned to develop an agricultural program--education, research and extension-- with a church group in Haiti. He will be stationed in Haiti, but maintain a mailing address in Havana, Florida, about 25 miles from Tallahassee.

5. A local medical group from the Tallahassee Memorial Regional Center, have recently visited Haiti in connection with an infant project. It is proposed to develop stronger linkages with this group because of possible relationships with this project.

Projected Efforts

A complete bibliographic review has been carried out, and several current documents on dietary work in Haiti have been obtained. However, the major drawback to work on this project has been the continued delay of our initial visit to the AID MISSION. This delay is regretted but it is hoped that this visit will materialize early in the fall. As soon as this visit is completed, work will be carried out as outlined in the original proposal.

Institution Kansas State University Project No. XXI KSU I
Fort Hays Branch Experiment Station

Project Title: Pearl Millet Improvement Program.

Project Leaders & Investigators: W. D. Stegmeier and T. L. Harvey.

Project Overview: The Fort Hays Station has 1540 ha of land, one-half of which is cultivated. Soils range from silt loams to silty, clay loams and are deep and fertile. Pearl millet breeding was started at the station in 1971. Plantings of pearl millet occupy 12 to 15 ha of land each year including 4 to 5 ha of isolated fields planted to mass-selected and recombining population materials and F_1 hybrid seed producing blocks. Most of the materials are planted on fallowed land; one ha can be irrigated. Project personnel include three technicians and one or two part-time workers during the summer.

Research Approach: The original materials used in the program included 285 plant introduction station lines, two varieties developed by Dr. Hugh Doggett, dwarf derivaties of these two varieties developed by Dr. A. J. Casady, and several forage inbred lines supplied by Dr. Glenn Burton. The world collection (1450 lines) is being grown as a population, recently, 82 items were received from ICRISAT.

Nearly all materials entering the program do not mature before frost in Western Kansas. After initial screening, selected materials are converted to dwarf, early-maturing plant types. Segregating progenies are advanced in either of two ways: 1) as inbred lines to be tested as parental materials in hybrid combinations, and 2) as mass-selected populations, random-mated for periods of two to four years followed by population improvement using recurrent selection programs.

The S_1 progeny performance testing method is presently being used. Winter recombination nurseries are grown in Puerto Rico or Hawaii and the S_0 and S_1 generations are grown at Hays. Selection pressure is applied in all three generations.

Five populations are being advanced by mass-selection and five populations are in S_1 improvement programs. A total of 597 items of A_1, B_1, and A_2, B_2 cytoplasmic

male-sterility reaction are planted in a backcross nursery. The male-fertility restorer nurseries contain 788 lines ranging from F_4 to F_{13}. Five isolated crossing blocks, each containing one male and 50 to 70 female lines, are producing F_1 seeds for tests on combining ability and agronomic studies. Over 400 F_1 hybrids were planted in yield and observation nurseries in 1980. An early-maturity conversion nursery contains the 82 introductions from ICRISAT and their F_1 hybrids. Screening for millet reaction to the greenbug aphid, Schizaphis graminum (Rondani), is conducted in the winter greenhouse.

Results and Projected Effort: Rates of advancement of desirable characteristics within the populations are ranging from poor to good. Grain yields, lodging responses, and plant heights of several F_1 hybrids during the preceeding three years have been comparable to adapted sorghum hybrids, however, year to year yield stability is a problem. Grain protein contents of the millets continue to be 1 to 3 percentage points greater than those of the sorghum checks at comparable grain yield levels.

Stand establishment on heavy soils is improving with increasing seed size and changes in machinery and tillage methods.

The better male-sterile lines in the program have the A_1 B_1 system. Problems have been encountered involving incomplete fertility restoration in several of the better F_1 hybrids having A_1 cytoplasms and there has been some difficulty in obtaining A_2 sterile lines that remain sterile under different environmental conditions. Reselection within some of these materials appears to be showing improvement. Several A_1 and R lines appear to have good combining ability, however, further testing is necessary.

INTSORMIL REVIEW

September 1980
Lubbuck, Texas

Physiological and Developmental Processes XII KSU 2
Edward T. Kanemasu
Kansas State University

Overview

I. Effect of plant height on sorghum (isolines) yields and water use - Manhattan

II. Effect of water on sorghum growth, yield components, and water use - Manhattan (cooperation with Nebraska)

III. Canopy temperatures of millet genotypes - Hissar, India (cooperation with HAU & ICRISAT)

IV. Canopy temperatures of sorghum genotypes - Hyderabad, India (cooperation with ICRISAT)

Procedure

I. Three isolines were planted in pure and mixed stands. Water use efficiency, photosynthetic light interception, flag leaf temperature, stomatal resistance, xylem water potential, dry matter production, and grain yield components were determined on the height isolines.

II. Four sorghum hybrids were studied on a point-source, continuous, variable watering system. Water use, growth, stomatal resistance, xylem water potential, canopy temperature, and yield components were determined a function of distance from the point source. Same hybrids were studied at Lincoln, Nebraska.

III, IV ICRISAT, Narayana Agricultural University and Kansas State University are cooperating in a project to determine the potential of using canopy temperatures as a selection technique in drought resistance. Millet genotypes being studied at Hissar and sorghum at Hyderabad.

Results

Advantages of short over tall sorghum genotypes include resistance to lodging and adaptation to mechanical harvesting. Grain yield comparison of sorghum height types are, however, inconsistent. Experiments were designed to relate sorghum height to growth and development in pure and mixed canopies in the summer of 1978 and 1979. The treatments were: the 1-dwarf, 2-dwarf, 3-dwarf, a 33% by weight mixed-intercrop and alternating rows of the height isolines. Water-use efficiency (WUE), photosynthetic light (PAR) interception, flag leaf temperatures, stomatal resistance, xylem-water potential, dry matter accumulation and grain yield of the height isolines in the pure, mixed and alternated rows were determined.

The plant population of approximately 175,000 plants/ha, gave leaf area indices greater than 3.7 from half-bloom through grain filling. Only the 3-dwarf plots had incomplete ground cover which allowed significantly higher PAR transmission than either the 1- or 2-dwarf canopies. Fewer tillers and open arrangement of leaves on the tall 1-dwarf plants allowed higher PAR transmission and, therefore, lower interception compared to the 2-dwarf canopy though these differences were not statistically significant. Intercepted PAR in the mixed and alternated rows were similar to that in 1- or 2-dwarf plots.

The water extraction profiles of the pure isolines were similar except the 3-dwarf plots allowed more surface evaporation because of incomplete ground cover. Tall plants had the lowest xylem-water potential and highest stomatal resistance, 3-dwarf plants had the reverse while 2-dwarf plants were intermediate. The tall canopy had the highest evapotranspiration in both seasons. The 2-dwarf plants had consistently the warmest canopy temperature of the isolines during peak insolation periods.

Differences in dry matter of the isolines were mainly in the stem fraction rather than leaves or heads. The tall plants produced about the same total dry matter as the mixed and alternated plots. Relationship of dry matter production to transpiration normalized with water vapor pressure gave slope factor (k) of 0.173, 0.222 and 0.296 mb for the 3-, 2- and 1-dwarf canopies. Tall plants had the highest WUE for dry matter but the 2-dwarf produced the most grain in both seasons. Tall plants yielded more grain in the mixed than in either pure or alternated canopies. The short 3-dwarf plants in the mixed plots were shaded and, therefore, yielded the lowest in dry matter and grain.

INTSORMIL REVIEW CONFERENCE
September 15-19, 1980: Lubbock, Texas

REPORT ON KANSAS STATE UNIVERSITY'S FARMING SYSTEMS PROJECT (KSU-3)

Overview

1.1 The project has been worked out in collaboration with the University of Udaipur in Rajasthan, India. It uses a farming system approach to the development of technological packages for small and marginal farmers (below 2 hectares) practicing dryland millet mixed cropping. Department involved are Agronomy, Agricultural Engineering, Agricultural Economics, Sociology, and Extension from Udaipur and Sociology/Anthropology and Agricultural Economics from KSU. In India the project will administered through Udaipur's Experiment Station.

1.2 Specific technical problems for research are 1), the compatibility of traditional implements with package requirements - i.e. line sowing and seed/fertilize drilling and 2), varietal response under low rainfall and fertility conditions. Specific socio-economic research problems are 1), the economics of technical packages 2), the social organization of production and the impact of innovation on income, distribution, employment, and meeting of basic needs and 3), the role of women in agriculture.

1.3 The role of women is a particularly significant dimension since they play a large part in agricultural operations and also quite often in decision making and management. Innovation affects men's and women's participation differently due to the sexual division of labor; and this has implications for distribution of income and also such things as child nutrition.

Research Approach

2.1 The farming systems approach assumes that a given innovation should not only be technically and economically feasible by itself but also must fit into the rest of farm household operations. Along with this technical dimension, the human element is considered: how people are organized in production and what the human correlates and consequences may be.

2.2 The farming systems approach moves from 1), a continuing micro-level descriptive analysis of technical socio-economic features in representative households and villages to 2), on-station experimentation and design through 3), testing of technologies with participant households to 4), extension of a tried and tested package to farmers at large. Each stage feeds into the next and also

feeds back to preceeding ones. The idea is to identify problems at the field level within a systems context to guide on-station research.

2.3 Ten villages will be selected for micro-level research. Forty farm households per village will combine into a sample of 400, out of which 100 will be small and marginal participants. The rest of the sample will be comprised of larger farmers and landless laborers for purposes of comparison and understanding the wider dimensions of the system within which small and marginal farmers operate.

2.4 University of Udaipur will provide 10 assistants with basic agricultural or agricultural economics degrees, one residing in each village. Three of the ten villages will also have a resident assistant with a degree is sociology. These thirteen assistants will conduct formal interviews, participant observation, and extension work. In addition statistical and secretarial support will come from Udaipur as well as faculty advice and participation. Drs. Michie and Benson will also be in field sites conducting research and overseeing, Dr. Benson focusing on women in agriculture.

Results and Projected Effort

3.1 To date there are no results since the project has not begun. Udaipur and KSU anxiously await USAID and Government of India (GOI) to make the necessary agreements and arrangements for work to begin.

3.2 Since "in-hand" time and funding resources are limited (and assuming USAID-GOI arrangements will be made soon), the project will perforce begin with testing (stage 3) technological packages already developed by Udaipur. Testing will be facilitated by subsidized inputs and on-site technical advice to participant small and marginal farmers. The descriptive analysis (stage 1) will be conducted simultaneously for basic data and monitoring. Both stages will feed into on-station research and design (stage 2). This allows for immediate short term results with the potential - dependent on continued funding - for a longer term project along lines discussed above.

Barry H. Michie
Principal Investigator
KSU Farming Systems Project

STORAGE AND PRESERVATION OF PEARL MILLET

Principal Investigators: Robert B. Mills, Dept. of Entomology
John R. Pedersen, Dept. of Grain Sc. and Industry
Kansas State University, Manhattan, Kansas 66506

Overview:

Laboratory research in the Dept. of Entomology and Dept. of Grain Science and Industry on biology and behavior of stored product insects (SPI) in millet, damage caused by SPI, varietal resistance to SPI, effects of threshing and handling on susceptibility to SPI, moisture/relative humidity relationships, insects and fungi in "bulk" storage, and simulated traditional storage containers.

Research Approach:

1. Laboratory research at KSU.
   a. Biology and behavior of SPI in millet.
   b. Susceptibility/resistance of millet cultivars to SPI; causes of resistance.
   c. Effects of threshing and handling methods on susceptibility to SPI and fungi.
   d. Moisture content/relative humidity equilibria of millet.
   e. Methodology of moisture testing for millet, esp. for field use.
2. Research at KSU Food and Feed Grain Institute's grain storage facility (nearing completion).
   a. Two 15 x 30 x 7-ft environmental rooms will be available for study of population development and damage by insects in "bulk"- stored millet (in-head and threshed).
   b. Study of simulated traditional storage containers in relation to susceptibility to infestation and damage by insects.
   c. Effects of threshing and handling methods on insect and mold infestations and damage.
3. Research in LDC's (will depend upon interests of cooperators).
   a. Year-around surveying of insect (and mold?) situations in storage; identification of species and estimation of damage.
   b. Testing local varieties of millet for resistance to SPI.
   c. Study and evaluating local storage facilities, customs, and control measures.

Results of research to date:

1. Infestibility of millet by 15 spp. of SPI. Largest number of progeny were produced by maize weevils, rice weevils, confused flour beetles, sawtoothed grain beetles, & cigarette beetles; greatest grain wt. loss was caused by maize weevils, rice weevils, granary weevils, lesser grain borers, and cigarette beetles.
2. Biology of Angoumois grain moth in millet vs. corn, wheat, or sorghum. Developmental period was 24% longer in millet than in sorghum, but similar to that in corn or wheat. Moths from millet laid fewer eggs and were smaller than moths from wheat or corn.
3. Progeny production of red flour beetles and maize weevils in various millet media. Flour beetles produced many more progeny in whole millet flour than in whole millet kernels, a mixture of whole and cracked kernels, or in cracked kernels (fines removed). Maize weevils produced many more progeny in the whole kernels, or in the mixture of whole and cracked kernels, than in the other media.
4. X-ray analysis of development of Angoumois grain moths, rice weevils, and maize weevils inside kernels of millet. Number of days to reach prepupal, pupal, or adult stages were determined. Angoumois grain moths which had entered kernels near the germ developed to adults in 14% less time than those that entered endosperm in the crown area of the kernels.

5. Effect of threshing method on number of progeny and damage produced by 5 species of SPI. Progeny production of maize weevils or Angoumois grain moths was similar in millet threshed by combine (w/ 10.8% dockage), lab thresher (1.8%), mortar (0.5%), or by hand (0.0%). Confused flour beetles, sawtoothed grain beetles, and lesser grain borers produced more progeny in combine and lab-threshed millet. Millet weight loss was related to number of progeny.

6. Size of weevils from millet. Maize and rice weevils reared in millet for 2 generations (following long-time culturing in corn and wheat, respect.) were 22 and 15% smaller (elytron length), respectively, than those reared in the culture grains.

7. Attractancy (olfactory) of millet products to red flour beetles. Flour made from fermented millet was much more attractive than unfermented whole millet, whole millet flour, or millet starch.

8. Ability of SPI to move through threshed millet. During 2 wk, confused flour beetles moved little from where they were introduced in a 10 x 30-cm column of millet. Maize weevils and sawtoothed grain beetles moved more through the millet, but still tended to remain in the area of the column where they were introduced.

9. Moisture content/relative humidity equilibria. Adsorption and desorption moisture content equilibria of millet have been determined in 5 relative humidities and 3 temperatures.

Projected effort:

1. Continuation of insect biology and behavior studies, including weevils, Indianmeal moth, and almond moth.
2. Testing lines of millet grown by KSU Agronomy Department at different locations for differences in resistance to SPI.
3. Studies of insects and molds in "bulks" (garbage cans or drums) at the Food and Feed Grain Institute storage facility, and of the effects of handling and threshing methods.
4. Studies of insect and mold infestations in simulated LDC storage containers.
5. Moisture testing methods having potential for use in LDC's
6. Encourage training of LDC personnel in grain storage and preservation by:
   a. Graduate students in degree programs at KSU.
   b. Participation of selected LDC personnel in the annual AID-sponsored 7-wk Grain Storage and Marketing Short Course.
   c. If arrangements can be made, conduct grain storage short courses in LDC's.

INTSORMIL - KSU-5

Our project objectives include 1) the development of an understanding of, and test procedures to determine, end use quality of pearl millet; 2) the nutritional evaluation of pearl millet using chemical and biological methods; and 3) the development of a knowledge base on the characteristics of the chemical components of millet.

Samples of "good" and "poor" quality pearl millet were obtained from Sudan. We found the Sudanese millet decorticated much easier than millet grown in Kansas. In general, millet was harder to decorticate than was grain sorghum. Those difference were due to difference in pericarp structure and possibly to differences in grain hardness.

Our studies of nutritional quality have included determination of amino acid composition of whole grain and milled fractions and the distribution of nitrogen among various protein solubility classes. In addition, a number of lines and population have been analyzed for vitamins and mineral. There appears to be little variation in vitamin content among various lines and population. Mineral contents varied more with P, K, and Mg being the major minerals in the grain. Pearl millet was notably low in Ca. The location of the mineral in the grain was also determined (Cereal Chem. 57: 150 (1980).

Feeding studies with rats of raw and processed millet showed that cooking did not decrease PER. Fermentation prior to cooking caused a reduction in PER. In general, milling to 67% extraction increased PER. Feeding studies with guinea pigs showed a significant decrease in liver cholesterol levels for those animals fed grain sorghum. Current studies are designed to comfirm that finding and determine what part of the grain sorghum

is responsible.

Characterization of the chemical components of pearl millet have included determing the free and bound lipid, the fatty acid composition of those lipids and the location of the lipids in the grain (Cereal Chem. 57: 271 (1980). The notoriously poor storage ability of pearl millet meal was studied. Contrary to some reports we found both hydrolytic (lipase) and oxidative racindity to be important (Cereal Chem. 57:275 (1980). A study designed to determine the basic properties of millet starch has found only small variations in amylose content (20 to 22%) among starches. Amylograms of the starches showed variation during the cooling cycle indicating that some of the starches may retrograde less then others (Cereal Chem: In Press). Certain populations of pearl millet were found to contain relatively high levels of α-amylase activity. The enzyme was purified and its properties described (Cereal Chem. submitted).

A review of the literature on pearl millet: its chemistry and utilization was published (Cereals for food and beverages. Ed. G.E. Inglett and Lars Munck. Academic Press. N.Y. 1980). A review of the chemistry of sorghum and millets is being prepared for publication in Advances in Cereal Science and Technology Vol. IV. It is to be published mid-1981.

International travel to the following countries has been a part of the project: Canada (2), United Kingdom (2), Germany, India (2 trips and several locations), Sudan (2), Senegal, and Nigeria.

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Seed and Seedling Vigor, Pearl Millet

Richard L. Vanderlip
Kansas State University, Manhattan, Kansas

The project "Improvement of Pearl Millet" was approved and funded as a 3-year program commencing 1 October 1977. This program was phased into the TITLE XII INTSORMIL project with enlargement of the program in the areas of plant breeding, drought tolerance and stress, a continuation of the seedling vigor and nutritional quality programs plus the addition of a Farming Systems Program.

One of the major cultural problems in the husbandry of pearl millet is stand establishment. This is a universal problem encountered in the Sahel region of Africa, semi-arid tropics of Asia, and here in Kansas. Seed vigor and seedling vigor are associated with stand establishment.

Objectives are to: 1) Identify seed and seedling characters associated with differential seedling vigor and field stand establishment; 2) Identify and evaluate germplasm with capacity to establish good stands under stress conditions - particularly temperature, moisture and high salt.

The approaches utilized are: 1) Utilize established laboratory techniques and procedures for stress prior to germination, to determine the correlation of test results with field establishment and seedling vigor; 2) Determine if seed size and density are related to seedling vigor, stand establishment, plant development and grain yield.

Laboratory and field tests were conducted during 1977 and 1978. Field tests were conducted at two locations, Manhattan, KS on a loam soil and at the Sandyland Experiment Field, St. John, KS on sandy soil. Laboratory tests were conducted to investigate the degree to which laboratory tests could predict field establishment of pearl millet. The laboratory tests included standard germination, electrical conductivity of soaked seeds, and stress tests of soaking seeds in ammonium chloride solution, soaking seeds in sodium hydroxide solution, artificially aging at high temperature and relative humidity and soil cold testing. The first year 20 varieties of pearl millet were tested; the second year a different set of 30 varieties were used.

Germination percentages from the stress tests were lower than those from standard germination as seeds of low vigor were killed after being subjected to adverse treatments.

Criteria used to evaluate vigor tests were: correlation with field establishment, and ranking millet varieties according to field performance. These criteria suggest that all laboratory tests used except the electrial conductivity test were able to screen vigorous from non-vigorous seed. Soaking of the millet seeds in 5% sodium hydroxide for 2 minutes prior to normal germination seemed to be the best vigor test although NH_4Cl, accelerated aging and standard germination were significantly similar in ranking the varieties.

In another study the seed characteristics of size and density were found effective for selecting the most vigorous seeds in a seedlot. Small seeds were closely related to poor seedling vigor and low yield. The best seeds were often not the largest, but were the larger half of the size range. Seed density was positively related to seedling vigor. The higher the density of the seed the greater the chance for survival. The effects of seed characteristics were most apparent during the early stages of growth and development.

In another study, early seedling stress tests are being evaluated for screening millet lines for drought tolerance. A student is presently at ICRISAT conducting part of his research on this project cooperatively with Dr. Fran Bidinger.

Results from these studies can be found in:

Seed Vigor Measurements and Their Use in Predicting Field Establishment of Grain Pearl Millet (*Pennisetum americanum*). Master's Thesis, Kansas State University, 1978. Gallus Joseph Mwageni.

Yield Comparisons of Pearl Millet (*Pennisetum americanum* (L.) Leeke) and Grain Sorghum (*Sorghum bicolor* (L.) Moench). Master's Thesis, Kansas State University, 1980. John Craig Palmer.

The Effect of Seed Size and Density on Field Emergence and Yield of Pearl Millet (*Pennisetum americanum* (L.) Leeke). 1980. John C. Gardner.

First Annual Report, October 1977-September 1978. Improvement of Pearl Millet. Kansas State University, Contract: AID/ta-C-1458.

Second Annual Report, October 1978-September 1979. Improvement of Pearl Millet. Kansas State University, Contract: AID/ta-C-1458.

INTSORMIL 1980 Annual Report, July 1979-March 1980. Sorghum-Millet Coordinated Research Support Program. Grant: AID/DSAN/XII-G-0149.

Agronomy Abstracts, American Society of Agronomy. 1979 Annual Meeting. Pages 107 and 115.

Eleventh Biennial Grain Sorghum Research and Utilization Conference. 1979. Page 51.

September 18, 1980

XII UK 1

UK-INTSORMIL Project Report

Title: Sociocultural Constraints in the Production and Consumption of GS/PM in Less Developed Countries

C. Milton Coughenour, Principal Investigator

The plan of the first year's project work has involved activity relating to two of the three project objectives:

1. Research on systems of sorghum/millet production, distribution, and consumption (Billie and Kathleen DeWalt, Co-Principal Investigators)

Due to failure in establishing the necessary LDC institutional linkages, we have not been able to initiate field work in the Sudan or elsewhere. Project work thus has been constricted, but it has been possible to compile previously published materials and to delineate a research strategy and model.

Library research to accumulate background information on the Sudan has resulted in two working papers. The first, "The Major Constraints in Inhibiting the Expansion of Dura Production in the Sudan" identifies four types of constraints which are hindering increased production of dura in the Sudan. These are: 1) resource constraints such as adverse climatic and geographic conditions and poor access to inputs; 2) infrastructural constraints such as poor transportation systems and poor markets; 3) institutional constraints such as poor extension services; and 4) technical constraints such as unsuitable production practices.

A second paper titled: "The Origin and Spread of Domesticated Sorghum in Africa with Special Reference to the Sudan" discusses the existing archeological, historical and botanical data available regarding the origin and spread of sorghum cultivation in Africa.

In addition, a bibliography of over five hundred references concerning the cultivation of sorghum and millet with special reference to Africa has been compiled. Information is provided on over 27 countries including the Sudan. The range of subjects addressed by these documents includes: nutritional qualities, pest and weed control, cropping and cultivation practices, post harvest treatment of the crops, country-wide descriptions of production, culture and breeding practices, growth studies, fertilizer usage, fertility improvement, production problems, intercropping systems and rainfall conservation. This bibliography is continuing to grow and we are now in the process of computerizing it.

During the Spring of 1980, K. and B. R. DeWalt conducted a seminar focused on the building of a research model and strategy for the study of sorghum and millet farming systems. Research team members also attended weekly seminar in the study of the Arabic language.

Finally, B. R. DeWalt travelled to Mexico for a series of meetings with representatives of INIA, CIMMYT, and ICRISAT to begin the process of setting up field sites in Mexico and Central America.

2. <u>Communication among agricultural scientists</u> (Larry Busch and W. Lacy, Co-Principal Investigators)

Since appropriate linkages for work with research centers in LDC's have not been established, the research has been done under the related Hatch project on the Communication Processes in the Agricultural Sciences. It has focused upon issues of research problem formulation, research goals, and expected beneficiaries of the U.S. Agricultural Research System. One aspect of this research, particularly relevant for the INTSORMIL project, concerns the relationship between international research and that done in the United States. As is relatively well known, both the international research centers and a number of national research systems in less developed countries were modeled upon the American system. Yet, the American system was borrowed without fully understanding either its workings or implications. Thus, one thrust of our research has been an examination of how certain themes developed in American research have been adopted, successfully or unsuccessfully, in international and national systems.

During the past year, we have also endeavored to collect secondary documents on research systems in LDC's in which sorghum and/or millet are major food grains. Many of these documents are unpublished or institutional reports and, thus, difficult to identify. Lacy spent some time at the East-West Center at the University of Hawaii, which has a useful collection of materials, and in consultation with members of the Food Systems Project including former staff members at ICRISAT. Several of the East-West Center staff are interested in issues regarding research organization and one student there has nearly completed a study of organizational development of the International Rice Research Institute. Busch visited ICRISAT as team leader of a group charged with setting up a conference on "Sorghum in the 80's." At that time, the possibilities for interviewing ICRISAT's staff members was discussed. However, ICRISAT officials felt it was an inopportune time to interview their staff. Similar interviews were planned with researchers in the Sudan, but have been postponed due to the lack of an official country agreement.

1980
INTSORMIL Review
Report

PROJECT TITLE: Seed Factors Influencing Germination, Emergence and Stand Establishment of Sorghum and Millet

ORGANIZATION: Seed Technology Laboratory, MAFES, Mississippi State University. Project No. XII - MSU-1(MIS-1505)

PROJECT OBJECTIVES

1. Analysis of emergence and stand establishment problems in selected sorghum and millet production areas to determine their causes and the relative importance and contribution of "seed" and "environmental" factors.
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.
4. Developement of procedures and techniques for screening sorghum and millet germplasm for superior seed quality properties which are suitable for use in breeding programs.
5. Training of selected LDC personnel in advanced studies. applied research methods, and in the interpretation and use of research data and findings.

PROJECT OVERVIEW:

The seed of superior varieties is the only crop production input that economically can be made available to the majority of sorghum and millet producers in the LDC's. This project will attempt to identify and as possible resolve seed related problems of both a physiological (environmental stress) and genetic origin which currently limit germination, emergence, and stand establishment.

RESEARCH APPROACH:

Initial emphasis has been assigned to objectives 2,3, and 5. Work is being concentrated in three areas; seed maturation and weathering, the seed and seed bed environment, and identification and/or influence of specific, heritable characteristics on seed and seedling performance. Following the development of more precise base line data for each of the three areas above, studies of the interactions of specific seed, environmental and genetic characteristics will be conducted. In keeping with Objective 5, graduate students from Kenya, Sudan and Brazil with specific interest in sorghum/millet research are currently assigned to studies supported in part by this project. It is anticipated that cooperation can be established with research and seed workers in Honduras to begin work on Objective 1 in early 1981.

RESULTS AND PROJECTED EFFORT:

Major activities to date include the review of literature, obtaining and multiplying seed, accumulation of equipment and evaluation of techniques.

Producing sufficient seed of acceptable physiological quality for our studies has been difficult; however, this problem has apparently been resolved. High quality seed of both self and open pollinated seed of approximately 400 sorghum lines and 40 strains of pearl millet(Zumo collection) have been or are being produced this season.

A soil microclimate simulator(SMS) has been constructed and its performance and accuracy verified. Construction of a rainfall simulator is near completion following evaluation of a similar mechanism at the USDA Soils Sedimentation Laboratory(Oxford, MS). Techniques for simultaneous screening of large numbers of lines for physiological quality have been developed and are being refined.

A preliminary study of the effects of weathering on seed quality was made in 1979. The lines in the GWT and ADIN were exposed to natural and simulated rainfall and high humidity in combination with field inoculation with selected fungal species during the late seed development period. Harvests were made at physiological maturity and 15 days later. The degree of seed deterioration induced by the treatments varied among lines. While deterioration was generally increased by inoculation with the selected fungal species, viability did not appear to be directly associated with level of fungal infection as determined by the bioassy methods. This study is being continued and expanded

Three additional studies will be initiated this fall utilizing the high quality seed produced. One will concentrate on those factors; i.e. seed quality, genetic variability, moisture and temperature stress and mechanical impedance which affect stand establishment. The second study will be used to characterize germination and seedling development over a range of sorghum genotypes. Investigations of heritable seed and seedling traits with potential to reduce field deterioration, improve germination, emergence and/or stand establishemnt will also be initiated.

INTSORMIL

Project XII-MSU-2 (MIS-1504), Sorghum Host-Plant Resistance and Genotype Evaluation.

Investigators: Dr. L. M. Gourley (Leader), Dr. J. C. Denis, Dr. N. C. Merwine, Dr. L. E. Trevathan, Dr. S. B. King, Dr. N. Zummo and Dr. H. N. Pitre.

Breeding and Genetics

The 58 lines in the 1979 Sorghum Elite Progeny Observation Nursery (SEPON) and 41 downy mildew resistant pearl millet lines collected in Africa by Zummo were increased in quarantine for distribution to other INTSORMIL projects. Some of the SEPON lines are being evaluated for grain mold resistance in this project and XII-MSU-1. The millets are being examined for diseases endemic to Mississippi, and a seed increase and observation are being conducted in the Kansas project. Other sorghum lines will be increased in quarantine this winter.

A seed increase of 348 sorghum cultivars was made in Puerto Rico for fall armyworm, fungal toxins and aluminum tolerance screenings. These screenings are now in progress.

From 353 F_5 lines screened for sorghum midge resistance in 1979, 57 B-lines were crossed into sterile cytoplasm in Puerto Rico and the BC_1 made in Mississippi this summer. Twenty-five of the most resistant R-lines were crossed onto Johnson's midge resistant A-lines in Puerto Rico.

Grain mold resistant (SEPON x U.S. elite) crosses will be segregated in Puerto Rico this winter. Selections from these F_2 populations will be evaluated for grain mold and other disease pathogens in Mississippi and Honduras in the future.

Pathology

Grain mold. Research is directed toward the fungi involved, time of infection, and panicle parts infected. The first major time of infection occurred during the week following anthesis. At three weeks post-anthesis almost all panicle parts were infected. Major fungi isolated in descending order of numbers were *Fusarium moniliforme*, *Curvularia* spp., *Fusarium roseum*, and *Phoma* spp. for the relatively cool, wet 1979 season and *Alternaria* spp., *Curvularia* spp., *Fusarium roseum*, and *Fusarium moniliforme* for the relatively hot, dry 1980 season. Related work either in progress or projected include: 1) development of culture media to separately isolate *Fusarium* species and cultivars, 2) use of ergosterol analysis for measuring grain mold severity, and 3) fungal inoculation techniques to increase reliability of grain mold disease assessment.

Root Disease Complex. A root disease of unknown etiology has severely reduced grain sorghum production in the Brown Loam area of Mississippi. Similar problems occur in Africa and possibly elsewhere. Initial research is on determination of potential pathogens associated

with roots. Fungal genera most commonly found are Fusarium, Periconia, and Macrophomina. Projected research will involve pathogenicity tests and soil fumigation.

Leaf Diseases. The USDA research facility at Meridian, MS, has been an excellent location for field assessment of several leaf diseases. Anthracnose has received considerable attention and resistance is now available and being used. Zonate leaf spot and rough leaf spot resistance screening is gaining attention because it is apparent that these diseases can be especially serious in humid areas where sorghum follows sorghum.

Pearl millet (41 lines) from West Africa was grown at Meridian in 1980 and several previously undescribed leaf diseases were observed and are being investigated.

Entomology

Weekly evaluations of 348 sorghum lines in whorl stages for resistance to attack by natural infestations of fall armyworm larvae were initiated with plants in the 3rd to 4th leaf stage. An additional 220 cultivars have been evaluated at least twice for feeding damage during late whorl stages. Thirty lines in the ADIN and 37 lines with resistant characteristics to specific insects and disease organisms were evaluated twice for severity of armyworm feeding damage. Seed will be obtained from desired genotypes and the plants will be evaluated in the greenhouse during the winter for fall armyworm oviposition preference or nonpreference and larval feeding damage.

A select group of sorghums (25 cultivars) of different morphological and physiological characteristic types were evaluated in the field for larval feeding damage. Observations of leaf trichomes revealed absence of prominent structures on lines examined. These cultivars and other selected material will be evaluated in leaf disc bioassay feeding studies with armyworm larval instars. Larval development will be measured on the different cultivars. Sorghum cultivars with indications of resistance to the fall armyworm will be included in further evaluations in 1981.

Replicated tests of midge resistant lines, 50 from Mississippi and 90 from Texas, and midge resistant hybrids, 30 from Mississippi and 50 from Texas, are being evaluated for midge damage.

INSTITUTION: Mississippi State University Project No. XII MSU 3

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

PROJECT LEADER: Mary Futrell

The Mississippi State University INSORMIL Project is concerned with the development of a general research approach which can deal with agronomic, economic , social, and nutritional factors which are involved in the introduction of improved varieties of grain sorghum in small scale farming systems. The area chosen for study is to be one in which grain sorghum is of considerable importance as a human food. Honduras has been selected as a feasible area because here, especially in the southern part, sorghum is regularly produced. An annual production in excess of 69,000 metric tons is found and more than 44,000 farms regularly grow sorghum for human consumption. Another criterion is that the area to be researched is one of small farms with an emphasis on subsistence farming with households forming the units of production and where community values are relatively homogeneous. It is assumed that this study is goal-directed in that it is concerned with the potential improvement of the quality of life, particularly in regard to nutrition.

Social data collected will be fairly comprehensive. It will include community leadership and social status, including the social status position of farmers who grow sorghum; the population of the community (or area under study); the composition of work groups related to farming activities; household and family structure and size; sex roles and decision-making patterns and attitudes and values related to farming, food and manual labor. Values and beliefs associated with food will include beliefs about nutrition value, status foods, a hierarchy of preferred foods, the hot-cold dichotomy, taboos and ceremonial usages. The focus will, of course, be on the role of sorghum foods in the over-all diet.

The collection of nutritional data and information concerning food habits will be a relatively complex undertaking. The nutritional status (specific nutrient deficiencies) of low income GS/PM consumer will be used as a yardstick for assessing agricultural development progress. This study will be conducted in the same villages where the sociologist, agronomist and other scientists are conducting research. This will be conducted in conjunction with local health services and local persons will be trained to detect signs of malnutrition. Simple methods of assessing malnutrition by simple arm measurement, weight, height, and head circumference will be used. Also, the presence of anemia, infant mortality, and infant feeding practices will be recorded. Nutrient intake of households will be recorded and analyzed. If severe malnutrition is found to exist, intervention programs such as weaning foods, education programs, etc. will be devised.

Data will be compiled on consumer preferences of grain to be used by the agronomist in the breeding program and for persons involved in quality testing and toxicology studies. Methods of preparation will be compiled, and all recipes standardized as to measurements. Other work in Honduras will be specifically related to the quality and digestibility of the sorghum tortilla. Preliminary methods of preparation have already been recorded so that work in this area can begin immediately. Close cooperation is planned with Lloyd Rooney from Texas A & M, who has developed a sorghum tortilla and would like it tested in countries where the tortilla is a major part of the diet. A preliminary trip to Honduras in January 1980 to the AID mission revealed that they were interested in help with sorghum tortillas.

Figure 1
TENTATIVE RESEARCH FRAMEWORK FOR HONDURAS INSORMIL PROJECT

Socio-Economic Mississippi State Univ.

Phase I Planning	Phase II Observation, Description, and Inventory Taking	Phase III Data Collection Using Appropriate Research Tools	Phase IV Analysis and Evaluation of Phase III Data.	Phase V Introduction & Testing of Improved Varieties	Phase VI Evaluation of Potential Adoption of New Varieties
Ongoing grain sorghum plant breeding program at Mississippi State University	AGRICULTURAL FACTORS: Physical & biological environment (water, radiation, soil, wind, topography, flora & fauna, weeds, pests, diseases)	Existing cropping system: Land use, tenure patterns, size of farms, cultural practices (tools, rotation, fallowing, fertilizing, harvesting, processing, storage)	Analysis of data to ascertain most significant interrelationships	Agricultural field testing of varieties selected on the basis of improved productivity and desirable characteristics for human consumption	Study of the implications of the adoption of new varieties:
Coordination of agronomic, social, and nutritional criteria for study	ECONOMIC: Resources & practices: Technological capability & knowledge, land & labor, support systems (extension, credit, policy, markets)	Productivity, importance & uses of sorghum (food, feed, fiber, etc.)	Findings used as basis for recommendations concerning the appropriate amount of change and the selection of an appropriate level of technology	Laboratory tests of grain samples used in traditional recipes, selection of most promising for field testing	Technological needs, yields, efficiency, environmental costs & benefits, economic changes (taxes, credit, subsidies), social costs & benefits (quality of life, family structure), nutritional costs & benefits.
	SOCIAL: Community social structure, household and family composition, sex roles, objective & subjective level of living, attitudes, traditions	Work groups, responsibilities	Realistic appraisal of individual, community, and infrastructure support for proposed change		
Selection of producer site for field study	NUTRITIONAL: Inventory of food types & preferences, preparation techniques, nutritional status, food & health beliefs	Quality of life: Level of living index (durable goods), Nutritional index (food use & beliefs)		Field testing of new varieties for food, respondents asked to evaluate for qualities liked and disliked, processing qualities.	
	Development of appropriate categories & research tools				

Best Available Document

INTSORMIL PROJECT REPORT

Project Title: Physiological Methods of Selecting for Drought Resistance in Sorghums

Investigators: C. Y. Sullivan, J. D. Eastin, D. G. Watts, W. M. Ross, C. A. Francis, USDA-SEA-AR and University of Nebraska, Lincoln

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 conditions.

Line source irrigation gradients are being used to develop different levels of water stress at Lincoln, Mead, and Tryon (Sandhills Ag. Lab.) in Nebraska and at Garden City, Kansas. Gradients are under development and dryland-irrigated screening is occurring at Sidney and Scottsbluff, Nebraska.

In studies on effects of drought stress at different stages of plant development the system is designed to apply uniform plot irrigation as desired. Field measurements include soil water use (neutron moisture probes) and ET estimates, plant water, osmotic and turgor potentials, leaf temperatures and diffusive resistances, net photosynthesis, leaf area and development, total dry matter production, seed weight and seed numbers. Weather is also monitored.

Root density and distribution are being determined on a limited number of genotypes at different stress levels by soil core sampling. Root development in hydroponic cultures is being compared to field responses.

Techniques for evaluating seedling stress resistance including heat and water stress and their interactions are underway in greenhouse and growth chamber experiments. Effects on shoot and root growth and photosynthesis are being evaluated including stress acclimation. Other greenhouse and growth chamber studies on plants grown to maturity are concerned with interactions between high temperatures and drought stress and effects on floral and seed development.

Results are inconclusive at this time, however, previous genotype screening with the irrigation gradient showed marked differences in yield response across the gradient. Some of these genotypes are being reevaluated with increased plant measurements. Diffusive resistance values were found to be as much as ten times higher in some genotypes under stress with transpiration reduced by as much as one-fifth of others.

(over)

Reduction in dry matter production of water stressed plants in the 1980 season compared to fully irrigated controls, during early grain fill, ranged from 20 to 37% with the greatest effect on late maturity genotypes.

Maximum root length and branching was found to increase as the water level was lowered in hydroponic tubes, and the values differed among genotypes. Field soil core sampling is aimed at determining whether this response is similar under field drought conditions. The tubes offer a more convenient method of screening for this characteristic.

In comparing the photosynthetic stability of selected stress resistant lines from population NP9BR, a stress of -10 bars resulted in declines in photosynthesis ranging from 20 to 60% reduction. Acclimation to drought stress in the vegetative stage was also evident from photosynthesis measurements. Photosynthetic rates of plants under stress were as much as 50% higher when preacclimated compared to controls. Indications are that this characteristic can be selected for.

INFLUENCE OF NIGHT TEMPERATURE ON RS 671
SORGHUM (OGUNLELA 1979)

(AMBIENT + 5C)

	G GRAIN/ PLANT	SEED NO	G GRAIN/GS3 DAY/PLANT
CONTROL	66.9	2659	2.09
PI_1 TO PI_7 1/	59.3 A	2333	1.85
	(11)	(12)	(11)
PI_8 TO FD_1 2/	53.4	2174	1.71
	(20)	(18)	(18)
FD_1 TO FD_7	48.0	1855	1.49
	(28)	(30)	(29)
FD_8 TO BL_1 4/	52.7	2176	1.66
	(21)	(18)	(21)
BL_1 TO BL_7	55.9	2223	1.80
	(16)	(16)	(14)

1/ PI IS PANICLE INITIATION (SUBSCRIPTS ARE DAYS)

2/ FL IS FLORET DIFFERENTIATION (STAMEN & PISTIL PRIMORDIA)

3/ PERCENT REDUCTION FROM CONTROLS

4/ BL IS BLOOM

INTSORMIL-COORDINATED RESEARCH
SUPPORT PROGRAM - GRAIN SORGHUM/PEARL MILLET

INSTITUTION: University of Nebraska
PROJECT TITLE: Grain Sorghum and Millet Response to Temperature Stress.
PROJECT LEADER: Jerry D. Eastin, C. Y. Sullivan, C. A. Francis, M. D. Clegg

Objectives, Results and Projections

1. Characterize the effects of temperature on developmental processes in sorghum and millet which dictate limitations to seed size and seed number, and simultaneously monitor and describe key physiological processes which control development.
   Results. Earlier growth room studies suggested sorghum yield reduction of 25 to 36% due to night temperature elevations of 5C. Field tests with temperatures regulated 5C above ambient for one week periods during panicle development reduced yields from 11 to 28%. The most severe reductions occurred during differentiation and development of the pistil and stamens. Yield reductions were paralleled by seed # reductions and reductions in plant metabolic efficiency.

   Growing roots apparently compete with the developing panicle for available assimilates needed to enhance the seed number component of yield. Comparative hydroponic root tests on 2 genotypes showed respiration was from 30 to 46% higher (over a temperature range of 25 to 40C) in a common hybrid compared to a drought tolerant hybrid. The average 38% higher root respiration rate (assimilate requirement) may detract from panicle development in the common hybrid.

   Temperature effect data on millet has not been summarized.

   Projection. Characterize contrasting genotypes for night temperature effects on yield and seed number to estimate the response range.

2. Objective. Attempt to develop screening techniques for temperature typing sorghum and millet to improve adaptation in existing zones and exploit potential of new areas. Breeders will try to use the techniques to develop cool tolerant and heat tolerant sorghum populations.
   Results. A sandwich-water tray treatment has been used to spot genotypes in S_1 progeny which germinate fast, grow fast and give contrasting developmental patterns. Plants from S_1 heads are being separated on the basis of large root (primary) - small top, medium root - medium top, and large top - medium roots.
   Projection. Another year of transplanting contrasting types to the field will precede testing under ecofallow field conditions to see if the large or medium root selections do better than others. If field observations suggest any one combination may be better, S_2 seeds could be bulked to form populations tending toward faster or slower root growth for further testing.

3. Objective. Test selected materials and newly synthesized populations in key U.S. and LDC locations where temperature extremes and drought currently limit production.

(over)

Results. Random mating of 8 populations from Texas, Puerto Rico, and ICRISAT continues under Nebraska temperature conditions.
Projection. Selections will be tried in LDC's as linkages are developed.

4. Objective. Attempt to evaluate temperature effects on plant metabolic efficiency.
Results. Simple seed growth systems suggest dark metabolism efficiency is temperature influenced. More effort is needed to test this.
Projection. The effect of sink size (seed #) on photosynthesis and respiration as they relate to metabolic efficiency will be tested.

5. Objective. Initiate experiments to quantitate temperature and drought interactions for yield and yield components.
Results. The first growth room experiments are now in progress.
Projection. More growth room studies will be conducted. Attempts will be made to control night temperature on a water gradient in Garden city, KS, to get field tests on water x temperature effects.

INTSORMIL -- PROJECT NU-3: GRAIN FILL PERIOD IN SORGHUM

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

Overview: The period of grain fill in sorghum is important in determination of seed size and appears critical in stability of yield. The time and rate of grain fill are components of the final yield which is attained in each genotype, and we are exploring the genetic variation and relative contribution of each of these components.

Specific Objectives:

1. Explore the 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 conditions in temperate and tropical zones.

Research Approaches:

1. A standard set of 56 hybrids, lines and populations has been tested over more than 50 environments, and the results are being evaluated for grain fill length and rate as a function of environment; the stability of yield as a function of these two parameters also is being evaluated.
2. A set of 10 commercial hybrids is being evaluated through growth analysis during the grain fill period in two locations to further relate these processes to yield.
3. Four cycles of mass selection for earliness and yield in a random mating population are being evaluated on an individual plant basis (two locations, three reps, 100 plants/rep) for a number of plant characters: GS2, GS3, height, panicle length leaf number, grain yield, stover yield, seed size. Both fertile and sterile plants are included in each cycle, and the potential for recombinations of extremes exists.
4. Identification of individuals with extremes in days in fill period in another unrelated population gives us the potential for comparison of this capacity in two backgrounds.

Testing Phase:

Testing of extremes awaits their selection, and we intend to make experimental hybrids which differ in length and rate of fill; the same comparisons will be attempted on a population basis by testing families over a number of locations. The results will determine the importance of the two factors and suggest how far this methodology should be extended in tropical locations.

Training Component:

Mr. Robert Mushi, a graduate student from Tanzania, is currently working on this problem with Title XII support. He will continue with applications in the national program when he returns to Tanzania.

INTSORMIL -- PROJECT NU-4: ADAPTATION AND YIELD STABILITY IN GRAIN SORGHUM

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

Overview: Yield stability in grain sorghum and pearl millet is critical for crops which are grown in less favored areas with limited moisture. Broad versus specific adaptation and the interaction of this adaptation with potential yields are relevant questions which must be considered by a breeder setting up a program in the developing world. And the question of yield stability is central to our thinking about crops grown under stress. These areas are being explored in grain sorghum.

Specific Objectives:

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 or pool for extracting lines.
4. Test widely adapted lines, hybrids and populations in a range of climatic and cultural conditions in temperate and tropical zones.

Research Approaches:

1. A standard set of 56 lines, hybrids and population was grown in 55 environments in 1978 and 1979 in Nebraska and Kansas. These environments differed in tempearture, rainfall, photoperiod, planting date, land preparation, irrigation applied, and plant density. Data include germination and vigor, height, leaf no., grain and stover yields, components of yield, dates of flowering and physiological maturity. These are being analyzed as a function of time and climatic conditions.
2. Correlations of yield and dry matter, as well as components of yield, with other traits are giving indications of what stability is related to in the plant, and how important adaptation may be.
3. Populations in the short season environment in Sidney (NE) are being selected for adaptation to the Panhandle; additional germplasm from Texas and ICRISAT are being evaluated for inclusion in the program. This additional variability is essential in making resulting selections and new populations useful to programs in the tropics.
4. Testing of materials will follow synthesis of new populations, selection of lines, and production of experimental hybrids. Initial testing in nearby temperate locations will be followed by broader testing in tropical locations, especially in high altitudes where materials from this program may have the best chance of application. Use of short-season materials may also be relevant in areas where an extremely short rainfall period makes this trait valuable as a drought-avoiding mechanism.

Training Component: One student has completed the M.S. degree and returned to Colombia. One Pakistani and one Indian student are working with support from the project, as well as two American students with experience in East Africa, and career plans to return to the tropics.

MINERAL ELEMENT EFFICIENCIES AND TOLERANCES IN SORGHUM AND MILLET

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

Methods for screening sorghum genotypes for mineral element efficiency and tolerance have been developed. Differential responses of plants grown in nutrient solutions, and in soils under controlled conditions have been compared. Field responses are also compared to laboratory responses where possible. The elements studied so far have been N, P, Fe, and Al. Parameters used to evaluate differential efficiencies and tolerances have been visual deficiency or toxicity symptoms, dry-matter yields, element concentrations and contents, dry-matter produced per unit element, and element distribution.

With respect to N, over 200% differences were noted among genotypes for the various parameters. Four genotypes considered to be efficient and inefficient for N were studied throughout their life cycles. Two of the genotypes that showed wide differences relative to dry-matter yields showed little difference in total N absorbed. Uptake rates and distribution of N among plant parts were markedly different for the two genotypes.

Large differences were also noted among sorghum genotypes for growth, P content, and distribution of P. Plants generally grew better with organic sources of P than they did with inorganic sources. Organic P, calcium tribasic phosphate, or potassium dihydrogen phosphate gave the largest differences among genotypes for responses to P and appeared to be good compounds to use when screening sorghum for P efficiency. As young plants, P efficient genotypes generally had lower root phosphatase activities than P-inefficient genotypes. The distribution of P among the leaves of P inefficient and P efficient genotypes was markedly different.

Sorghum genotypes screened for Fe efficiency showed greater differences if added P or NO_3^- as the source of N were used to impose Fe stress on plants. Genotypes showed wide differences for Fe efficiency. A number of Nigerian sorghum genotypes showed fewer Fe deficiency symptoms than many U.S. genotypes.

Of 96 sorghum genotypes screened for Al tolerance, only 11% showed much tolerance to Al. In another study with a sorghum population (NP16), only about 10% of the S_1 progenies showed much tolerance to Al. Aluminum tolerance ratings as determined in nutrient solutions were similar to the plant responses when grown in an Al toxic soil in the field. When Al intolerant and Al tolerant male lines were crossed to two common female lines, Al tolerance was noted in the hybrids with the Al tolerant male parents. Al tolerance appeared to be dominant and susceptibility recessive in expression. Methodology on improvement of Al tolerance screening showed that good differential responses among genotypes could be obtained on 7 to 10 day old plants.

Studies are being continued on understanding differential responses of genotypes to mineral elements, the inheritance of these traits, and the feasibility for incorporation of the desirable traits into improved germplasm. With these screening methods, considerable germplasm will be screened for differential responses to specific mineral elements. Cooperative efforts with scientists in India, Brazil, and Nigeria have been initiated and cooperative effort with other countries is anticipated.

INSORMIL REPORT
Sept. 1980

Nitrogen Uptake in Sorghum and Millet

Jerry Maranville, Principle Investigator

Ralph Clark, Jerry Eastin,
Charles Francis, Bill Ross
Cooperators

Lack of adequate capital, transportation, and technology can hinder proper fertility practices in the LDC's. When nutrients cannot be applied due to one or more of these reasons, improvement in production could be made by using more efficient genotypes and improved production practices.

The objective of the current research are three: 1) identify sorghum and millet genotypes which are capable of producing high rates of growth and good quality grain under limited 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 between N metabolism and environmental parameters such as light, temperature, and water.

The research approach has been to first define 'N efficiency'. We use a) NE_1 - total dry matter per unit N uptake, b) NE_2 - total grain per unit N uptake, c) TRANS - translocation efficiency or N partitioning, and d) NE_3 - product of (a) x (b).

The first experiment was conducted using 12 sorghum hybrids from 3 A-lines and 4 R-lines. The results showed a 20% difference between the least and most efficient for NE_1 at maturity. Less difference between the extremes appeared for NE_2 or NE_3. Environment strongly influenced hybrid ranking and each N criteria ranked hybrids differently (see reference).

A second study was conducted where 100 hybrids were screened (10 A-lines crossed to each of 10 R-lines) to get a broader range of material to study physiologically. This study showed that there were superior A-lines and R-lines for 'N efficiency', as judged by performance of the F_1. Thirty-six of these hybrids have been retested for two years under high and low N fertility and high and low moisture to observe the consistency of performance and note the environmental modification.

A similar approach is being used with the millets. Foxtail (Setarica italica), proso (Panicum miliaceum), and pearl (Pennisteum glaucum) are being compared for NE. Environmental parameters include high and low N fertility and high and low soil moisture. The 1980 season is the first year of the study.

Several physiological investigations are being conducted in greenhouse and growth chamber facilities. These include studies on N level as affecting transpiration and visa versa, studies on N source as affecting metabolism using contrasting N efficient types, studies on atmospheric and root temperature as affecting N uptake and metabolism. A field study related to nitrogen use is being conducted by Dr. Max Clegg where sorghum is being grown in rotation with soybean.

Cooperative efforts with India and Nigeria are being pursued. We anticipate a broadening of this cooperation with other countries.

Reference:

Maranville, J. W., R. B. Clark, and W. M. Ross. 1980. Nitrogen efficiency in grain sorghum. J. Plant Nut. 2 (5): In press.

PROJECT XII UN 7. Recurrent Selection.

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

Plant Breeding with Random-mating Populations

Population improvement, using genetic male sterility for forced cross pollination, has been undertaken to develop superior grain sorghum germplasm. Our first recurrent selection studies have involved family selection and evaluation and mass selection with higher grain yield, increased insect resistance, improved grain quality, and more efficient mineral uptake as objectives.

Half-sib, full-sib, and S_1 family yield evaluations have been made from the C_0, C_1, and C_2 of NP3R; C_3 families were derived in 1980. Excessive brown seed and tall plants have been noted due to recombination of complimentary B and Dw genes, respectively, but deciduous spikelets due to complimentary Sh genes have been rare. A 2-year test of the C_0, the three C_1, and the three C_2 populations showed a 19 to 26% yield increase in the C_1 over the C_0, primarily due to increased height, but retained a 10 to 17% increase in the C_2 over the C_0 when selection pressure was applied against height. The C_3 populations are included in a comparative trial in 1980. Additive genetic yield variance in C_2 half-sib families and additive-type variance in C_2 S_1 progenies equalled their respective C_0 families, but dominance genetic yield variance in full-sib families disappeared entirely in the C_2.

An M.S. student is evaluating 60 F_1 hybrids made from crossing 10 S_6 R-lines selected in Nebraska from NP3R, 10 selected in Arizona, and 10 component lines of NP3R to two male steriles. Based on observations of this material and of S_5 inbreds from the population RP1R, lines selected from populations are as good as lines selected from F_2's. B-lines also have been developed (from RP2B), and BC_4 A-lines with satisfactory cytoplasmic male sterility were derived in 1980.

A Ph.D. thesis problem grown in 1979 and 1980 involves 114 topcrosses made from 19 A-lines and 6 unrelated populations. The experiment primarily considers general and specific combining ability of the parental groups.

In cooperative work with Iowa State, S_1 progeny testing of NP11BR artificially infested with European corn borers increased the number of resistant families from <1 to 6% in the zero class and from 4 to 18% families for the 10% or less infestation classes in three cycles; the progress indicates that several genes are involved. S_1 progeny testing was successful several years ago in the development of the once greenbug-resistant populations, RP1R and RP2B.

Mass selection of fertile plants for high and low grain protein in NP7BR has reached the C_4. The eight selected populations and the C_0 are being evaluated for protein and yield in 1980. Evaluation of earlier cycles showed gains in high and low protein selection accompanied by negative correlations with yield. Protein-yield tended to remain constant.

NP16BR S_1 families have been screened in the laboratory for Al tolerance, and the best S_1's have been recombined. Screening of two other populations for Al and Fe efficiency is being done cooperatively in Georgia.

Projected breeding work includes continuation of the long-term yield comparisons of half-sib, full-sib, and S_1 family testing with NP3R. Mass selection also will be pursued. Further evaluation of populations will be made through test crosses of A-lines to S_1's from the populations. A reciprocal recurrent selection scheme involving B and R populations will be considered. Future work on grain quality will be concerned with S_1 family evaluation for protein-yield and/or metabolizable energy rather than protein alone. Consideration will be given to breeding for improved N efficiency and to heat-cold-drought stress pending perfection of screening techniques. Breeding for Al and Fe efficiency will continue.

Allozyme Frequencies and Patterns in Sorghum Populations

Electrophoresis techniques exist for examining allozyme frequencies and patterns in a number of plant species. Only recently have the techniques been used to study changes occurring in populations undergoing recurrent selection. To our knowledge, nothing has been done in sorghum populations. Therefore, we have initiated a program to study allozyme patterns in sorghum to gain greater insight into what is occurring in populations that are being selected for high grain yield on a cyclical basis. We can examine allozyme genotypes and patterns in each component used to create the NP3R random-mating population, we can examine the synthesized (C_0) population used to initiate selection studies, and we can examine improved C_3 populations resulting from three cycles of half-sib, full-sib, and S_1 family selection. Information obtained will enable us to (1) determine how allozyme patterns are inherited in sorghum, (2) detect allele and genotype frequencies in male-sterile and male-fertile components of the populations, (3) detect shifts that have occurred in allele frequencies and patterns and relate that to genetic drift or to effects of selection for high grain yield, (4) determine mating systems occurring in "random-mating populations" through use of genetic male-sterile plants, (5) check for linkage disequilibrium initially and after selection, (6) look for patterns that may reflect some insight into plant characteristics, e.g., heat tolerance, disease resistance, etc., (7) make use of allozyme patterns as measures of genetic diversity in populations or germplasm collections, and (8) make use of allozyme patterns to detect seed contamination or outcrossing in pure lines. The findings should be extremely useful in evaluating sorghum improvement through recurrent selection, a procedure that holds promise for developing nations as well as for the U.S.A.

Intsomil Review - Lubbock, Texas

September 15-19, 1980

Agricultural Climatology of Sorghum

R. E. Nield -- University of Nebraska

OBJECTIVES:

1 Describe the growing cycle of grain sorghum in terms of climatic requirements.

2. Complete a comparative climatological analysis of sorghum growing seasons and regions in the United States.

3. Characterize and categorize climatic conditions in seasons and regions growing sorghum in developing countries throughout the world.

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

PROGRESS AND PLANS:

Growing degree day-phenology models have been developed for hybrids NB505, RS626 and RS671 from observations on a series of plantings made on a seasonal temperative gradient in Nebraska. Included in observation plots this season are 5 other hybrids that represent the complete range of maturities grown in the M.S. from central South Dakota to southern Texas. This work relating to objectives 1,2, and 4 is the M.S. thesis program of Miss Joan Logan former Peace Corps worker in Ecuador who is very interested in international agriculture.

Next January these 8 U. S. hybrids plus 2 local strains will be planted on an altitudenal temperature gradient at 5 locations in Tanzania by Mrs. Margaret Mkuchu, a second M.S. student in the project who will complete the thesis portion of her program in Tanzania. This work relates to objectives 1, 3, and 4.

One serious problem limiting application of some types of weather-crop models is the lack of certain type of environmental data. This is true for models requiring data from sophisticated instrument measurements, particularly in many developing countries where sorghum is an important food crop. A computer program has been developed to calculate daily values of temperative, growing degree days, precipitation and evapotranspiration from monthly weather summaries that are more commonly available in developing countries. Such data have been used to study the respons of different hybrids at a single planting data and the response of a single hybrid at different planting dates. Preliminary analysis have been made comparing the response of hybrid RS626 at Fairbury, Nebraska and Dadoma, Tanzania and Lubbock, Texas and Kadugli, Sudan.

Project No. XII UN 9

Institution: University of Nebraska

Project Title: Protoplasts in Resistance Screening

Project Leader: J. E. Partridge

Overview of Project:

In the short range to establish a method to regenerate sorghum and millet plants from protoplasts and concurrently to evaluate protoplasts as a means for selecting for resistance to selected diseases through treatment with specific fungal metabolites.

In the long range to effect the Parasexual Hybridization of sorghum and millet in an effort to transfer desirable agronomic and resistance characteristics to sorghum.

Research Approach:

1.) Establish callus cultures of sorghums which are resistant or susceptible to known pathogens.
2.) Establish cell suspension cultures.
3.) Establish protoplast culture method, which enable regeneration.
4.) Treat protoplasts with specific fungal metabolite.
5.) Regenerate survivors of fungal metabolites.

Results and Projected Effort:

Callus cultures have been established as have conditions for cell suspension cultures. Regeneration of plants from callus has been achieved; however, regeneration of callus from protoplasts has not yet been accomplished.

As a method is developed for regeneration and screening we will also look toward developing procedures for evaluation of materials for drought tolerance as well as disease resistance.

Cogent to, but not directly a part of, this funded effort, we are: a.) Cooperating with the ICRISAT downy mildew nursery in evaluating materials, b.) Assisting the Nebraska Sorghum Physiology group with disease problems, and c.) Conducting field experiments toward an understanding of Stalk Rot of Sorghum.

September 12, 1980
XII PRF 1

Purdue University Agricultural Economics Department Project No. DSANGO149

Project Title: Socio-economic Constraints to Sorghum and Millet Production and Utilization: Risk Government Policy, Consumer Preference and the Marketing System.

The objectives and research approach and the specific activities proposed for the first year are presented (in 3 pages) in our first annual report. Our activities this year have included training Professors Schrader and Lang in Marketing of sorghum and millet in West Africa and in French language. They are also reviewing the marketing research and have made a first visit to the field; they have proposed an outline for a marketing study in Upper Volta. Purdue's Farming Systems Unit in SAFGRAD is expected to collaborate in this research in CY1981.

The transcript of the proceedings of the two day workshop has been typed. It now has to have a second editing to reduce it to a more manageable length. The workshop was a useful beginning of dialogue and, if the proceedings are read by the INTSORMIL researchers, we should overcome some of what was lost by the timing which prevented a greater attendance of biological scientists.

We were unable to get the supplementary questionnaires on decision making by small farmers into the field before survey workers on the Purdue West African Program (PWAP) quit. We expect to have more opportunity in the future.

Mr. Robert Wilson is in the Gambia gathering data, in a GOG project, on pest management costs and returns in millet and sorghum in the Casamance. The data will be used with the Sahel farm model developed by Niang and McCarl to evaluate the alternative pest management strategies.

The work with the University of Bordeaux will be finished in Oct. 1980 and we expect to have a report before the end of the year. We would like to try to work on a longer term with CMDT (Mali) and the CFDT (Upper Volta) on survey design and analysis of sorghum based farming systems, in order to try to identify the conditions under which farmers will intensify their production. We would start with training of the African staff.

We have a partial synthesis of the data on women's work in food preparation and expect to finish it early next fiscal year.

It seems that the West African women have a system of treatment of grain with lye that detoxifies the tannin. However, varieties with greater bird resistance are urgently needed.

We propose to hold an essay competition, if the executive of INTSORMIL approves, among the members of the Purdue West African Projects who have had field experience, to provide a set of essays on farmers' perception of risk and adaptation to it in the different areas of W. Africa in which we have worked. This is in partial fulfillment of one of our objectives.

Next year we propose to:

- Continue our present activities as reported above.
- Review the results of the PWAP surveys to synthesise the factors involved in choice of varieties of sorghum and millet by farmers.
- To seek opportunities to collaborate with our sociological and agronomic colleagues in field research.
- Initiate the work with CMDT and CFDT by training their staff at Purdue in survey design and analysis.

INTSORMIL PROJECT SUMMARY - September, 1980

INSTITUTION: Purdue University PROJECT NO. X11 PRF 2

TITLE: Studies on mechanisms of disease resistance and susceptibility using pathotoxins and screening for improved resistance to fungal pathogens.

PROJECT LEADERS: Larry D. Dunkle and Herman L. Warren

SUMMARY OF RESEARCH

I. Sensitivity to Periconia toxin in World Collection of Sorghum

Milo disease, a root and crown rot caused by *Periconia circinata*, is unique to the U.S. The origin of susceptibility, which is determined by a single semi-dominant gene in the milo group of sorghums, is unknown. Although mutation to resistance (*Pc*-*pc*) has been noted by Schertz and Tai, the mutation to susceptibility (*pc*-*Pc*) has not been detected. Thus, the *Pc* gene may have been present in the original milo germplasm brought into this country ca. 1890.

Because susceptibility to *P. circinata* is genetically determined by the same mechanism as sensitivity to the host-specific toxin produced by that pathogen, the toxin can be used reliably to screen sorghum cultivars for susceptibility to milo disease. Results of experiments in which seedlings of materials in the World Sorghum Collection (obtained from Drs. A. Sotomayor and G. Lovell) were bioassayed with purified *Periconia* toxin showed that two cultivars of *Sorghum bicolor* out of the 32 tested were sensitive to the toxin. One of the lines (IS 9740) was from India; the other (PI 285043) was from Nigeria. Of the species closely related to *S. bicolor* that were tested, none was sensitive to *Periconia* toxin. These studies may be pertinent, not only to locating the source of the *Pc* gene, but also to defining the origin of the durra and milo races of *Sorghum bicolor*.

II. Periconia toxin: Purification and Characterization

Procedures were developed for purifying the host-specific toxin produced by *P. circinata*. Chemical characterization and structure determination by mass spectroscopy and NMR are underway. The purified toxin is being used in studies to determine the mechanism of action of the toxin on susceptible sorghum genotypes.

III. Sorghum Downy Mildew: Germination of Conidia

The effects of antibiotics that inhibit protein or RNA synthesis on germination of conidia of *Peronosclerospora sorghi* were determined. The conidia were sensitive to most of the antibiotics tested. Particularly noteworthy was the sensitivity to the antibacterial drugs, streptomycin and erythromycin. These experiments comprise some of the preliminary studies on host/parasite relations in SDM.

I. Response of *Sorghum bicolor* to *Periconia circinata* toxin

A. Materials *sensitive* to *Periconia* toxin

Designation	Origin
IS 9740	India
PI 285043	Nigeria
'Colby' Milo	(US)
Standard Yellow Milo	(US)
Standard White Milo	(US)
Dwarf Yellow Milo	(US)

B. Materials *insensitive* to *Periconia* toxin

Designation	Origin	Designation	Origin
PI 217674	Sudan	IS 158	India
PI 217760	Sudan	IS 2046	India
PI 284974	Argentina	IS 2276	India
PI 284975	Argentina	IS 2900	India
PI 285039	Nigeria	IS 2994	India
PI 297149	Uganda	IS 3982	India
PI 297151	Uganda	IS 6928	India
PI 337674	Ethiopia	IS 8234	India
PI 337683	Ethiopia	IS 8239	India
PI 338196	Venezuela	IS 8717	India
PI 338197	Venezuela	IS 8746	India
PI 267504	India	IS 9327	India
PI 267525	India	IS 9530	India
		IS 9699	India
		IS 9796	India
		E 35-1	India
		SC 108-3	India

II. Related *Sorghum* species *insensitive* to *Periconia* toxin

Species	Designation	Origin
S. arundinaceum	PI 164089	Brazil
	PI 186570	Nigeria
	PI 199869	So. Africa
	PI 302242	Burma
S. caudatum	PI 282834	Chad
	PI 282836	Chad
S. niloticum	PI 196890	Ethiopia
S. sudanense	PI 220969	Argentina
	PI 250104	Egypt
	PI 255739	Turkey
	PI 302224	Nigeria
S. verticilliflorum	PI 185573	Japan
	PI 213900	Kenya
	PI 213901	S. Rhodesia
	PI 247723	Zaire
	PI 154832	?
	PI 226096	?
	PI 300120	?
	PI 302231	?
S. virgatum	PI 215792	Dominican Rep.

INTSORMIL - COORDINATED RESEARCH

SUPPORT PROGRAM - GRAIN SORGHUM/PEARL MILLET

INSTITUTION: Purdue University PROJECT NO. XII PU 3

PROJECT TITLE: 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

PROJECT LEADERS: J. D. Axtell and A. W. Kirleis

PROJECT 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.

BRIEF RESULTS BY OBJECTIVE:

1. Drs. Kirleis (Purdue) and Rooney (Texas A&M) observed and studied traditional sorghum food preparation and processing in West Africa (Mali and Upper Volta). Trip report is attached. Drs. Axtell (Purdue) and Miller (Texas A&M) observed sorghum grain milling and preparation of Ugali and Ugi in Tanzania. Preparation of several sorghum foods in Sudan was also studied. Samples of sorghum foods prepared in Tanzania and Sudan by traditional village methods were collected for laboratory and biological evaluation of digestibility and nutritional quality.

2. Research is in progress to develop methods for screening for kernel hardness of sorghum. Kernel density measurements, vickers hardness tests, and utilization of an image analyzer to determine the proportions of floury and vitreous endosperm are presently being studied. These physical properties will be related to kafirin protein in the kernel in an attempt to correlate chemical with physical properties that relate to kernel hardness. These properties have been linked to both milling and food quality of sorghum.

3. We are presently conducting basic studies on the kafirin protein fraction in sorghum. This work includes: (a) develop purification methodology for extraction of kafirin proteins, and (b) analyze kafirin proteins with respect to molecular weight, charge heterogenity upon iso-electric focusing and begin determining N-terminal amino acid sequences.

4. Progress has been achieved in the development of vitreous endosperm, high-lysine sorghum lines from P-721 opaque. Modified endosperm selections were consistently higher in kernel weight and grain yield, and lower in both percent protein and lysine concentration. Total protein yields and total lysine yields of the modified endosperm selections were only 1 percent and 4 percent lower, respectively, than that of their opaque checks. Grain yield of selected P-721 opaque derived lines has been significantly improved and now approaches yield of normal endosperm lines.

5. The potential for utilization of the Ethiopian high-lysine gene as a weaning food must be re-evaluated in view of Dr. Graham's results on the digestibility of sorghum in infants and young children. A search has been made for a laboratory system which would give the same low sorghum digestibility values observed in children. Weanling rats could not be used, since they digest both cooked and uncooked sorghum proteins efficiently. However, pepsin solublized cooked sorghum proteins as inefficiently as did the young child. By comparing pepsin values for cooked and uncooked gruels, it was found that heating sorghum gruel markedly reduces its pepsin digestibility.

6. Several students have received graduate training at Purdue and are currently involved in international crop improvement programs. A partial list includes the following:

Dr. Dallas Oswalt - Training Officer for ICRISAT in Hyderabad, India
Dr. Sam Mukuru - Sorghum Breeder for ICRISAT at Ilonga, Tanzania
Dr. Vartan Guiragossian - ICRISAT Sorghum Breeder for Latin America, stationed at CIMMYT (El Batan, Mexico)
Dr. Gebisa Ejeta - Sorghum Breeder for ICRISAT at Wad Medani, Sudan
Dr. R. Jambunathan - Head of Biochemistry at ICRISAT, Hyderabad, India
Dr. Paul Christensen - Farming Systems Agronomist at Ouagadougou, Upper Volta
Dr. Bantayeu Gelaw - Maize Breeder at CIMMYT (El Batan, Mexico)
Dr. Rameshwar Singh - Sorghum Breeder at G.B. Pant University of Agriculture and Technology, Pantnagar, India
Dr. Robert Schaffert - Sorghum Breeder for EMBRAPA, Sete Lagoas, Brazil
Dr. Antonio Sotomayor-Rios - Research Geneticist at Mayaguez, Puerto Rico

September 18, 1980

XII PRF 4

Project Title: Enhancement of High Tannin Sorghum Utilization

Institution: Purdue University

Project Leaders: Dr. Larry Butler, Department of Biochemistry, Purdue University
Co-Principal Investigator, Dr. John Rogler, Department of Animal Sciences, Purdue University

Statement of the Problem: Tannin in sorghum grain generally benefits sorghum production (tannin is a natural protective agent against several environmental challenges), but restrains sorghum utilization because of its antinutritional effects.

Overall Objective: To eliminate or minimize the antinutritional effects of tannin in sorghum while maintaining or increasing its beneficial agronomic effects.

Approaches: Chemical, physiological, and genetic; all evaluated nutritionally.

Summary of Results:

Chemical - We have developed several new assays and modified others to provide specific chemical information about different tannin components. We fractionate tannin components on the basis of their solubility, their affinity for proteins and protein-like polymers, and their chromatographic properties. We have shown that purified condensed tannin from sorghum can precipitate up to fifteen times its own weight of protein. High tannin sorghums typically contain only about five times as much protein as tannin. When aqueous solutions of egg or serum proteins are mixed with ground high tannin sorghum, considerable amounts of the added protein are precipitated by the tannin. The strength with which tannin binds proteins is surprisingly dependent on the nature of the protein; relative association constants differ by at least four orders of magnitude. This unexpected protein specificity of tannin-protein interactions suggests that tannins function in plants in a manner analogous to antibodies in animals. The strength of the association is dependent upon the protein's content of proline, which disrupts the α-helix causing a looser, open structure, as well as provides a site for establishment of an unusually strong H bond.

Another aspect of our chemical approach is "detoxification". We have shown that several alkaline materials including extracts of wood ashes, when applied in aqueous solution to high tannin sorghum (whole grain) in small amounts so that all the liquid is readily absorbed, largely eliminate the chemically assayable tannin within a few days. In several cases the weight gains of rats or chicks on the treated material were equal to those on low tannin sorghum. Simply cooking the sorghum by several techniques did not improve the nutritional quality of high tannin sorghum, and in some cases even worsened it.

Physiological - Some lines of sorghum have quite high tannin levels at immature stages, and much lower levels at maturity. Such lines may provide an attractive combination of bird resistance and nutritional quality. We are currently testing twenty-four lines by five chemical assays throughout the maturation process, and eight of these are being evaluated in a bird resistance field trial. Feeding trials will begin soon. We find proanthocyanidins chemically similar to tannins in other tissues; sixteen of the forty-eight lines being tested have these materials in leaf tissue, some at quite high levels. Preliminary studies show that the levels of tannins and related materials increase significantly on wounding; we hope to extend these observations to the response to infection by various pathogens.

Genetic - We observe extreme variability of sorghum lines with respect to tannins and chemically related materials. Several polyphenolic components appear to be under independent genetic control. When these components are characterized with respect to their agronomic (e.g. bird repellancy) and nutritional effects, it may be possible to develop lines with the desired combination of good nutritional quality and agronomic properties. The group II sorghums may represent a first step in that direction.

Project Title: Enhancement of High Tannin Sorghum Utilization

Institution: Purdue University

Project Leader:

Principle Investigator: Dr. Larry G. Butler
Co-Principle Investigator: Dr. John C. Rogler

Objectives:

1. To determine the effects of stage of maturity on the tannin content and biological value of high tannin sorghum.

2. To determine the effects of feeding high tannin sorghum to laying hens and the efficacy of methionine in overcoming these effects.

Summary of Results:

1. Low tannin (RS610) and high tannin (Savanna and 6881) sorghums were harvested at 30 (immature) and 60 (mature) days past half-anthesis. Immature sorghum contained considerably more tannin by two different assay methods than mature sorghum. In feeding trials with both chicks and rats, low tannin sorghum (LTS) was superior to high tannin sorghum (HTS) at both stages of maturity. Immature HTS was greatly inferior to mature HTS for both the chick and the rat, whereas immature LTS was slightly superior to mature LTS for the chick and of equal value for the rat. Since all sorghums were compared on an equal protein basis, the differences in performance between HTS and LTS as well as immature and mature HTS apparently can be attributed to tannin content.

2. In an experiment with laying hens, LTS (RS610) and HTS (Savanna) were compared on an isonitrogenous basis within each of three protein levels (11.5, 13.0 and 14.5%). At all protein levels, diets containing HTS greatly reduced egg production. Supplementing a HTS diet with 0.2% methionine improved egg production up to a level approaching that of hens fed a LTS diet similarly supplemented. These results agree with earlier studies which demonstrated that methionine supplementation was an effective means of overcoming the growth depressing effects of HTS in young chicks fed sorghum-soybean meal diets.

INTSORMIL REVIEW

September 15, 1980

INSTITUTION: Texas A&M University PROJECT NO. XII TAM 1

PROJECT TITLE: Plant Breeding and Genetics - Productivity

PROJECT LEADER: F. R. Miller

INVESTIGATORS: P.W. Morgan, R.A. Creelman, J.W. Johnson, D.T. Rosenow

PROJECT OBJECTIVES:

1. Develop sorghums with wide adaptation and stable yields.
2. Determine involvement of phytohormones in control of maturity, sex expression, height, root development, tillering and other growth responses related to yield.
3. Determine effects of night temperatures on sorghum growth.
4. Determine relationship between yield and photosynthetic activity.

Summary of approaches and results:

A 49 entry, 3 rep yield trial (Tropical Adaptation Trials-TAT) containing materials selected from the breeding program and having adaptation to tropical and temperate environments was prepared and sent to 9 international and 6 domestic locations in 1980. This trial has 9 parental lines and 40 F_1 hybrids made up of elite US and Indian materials. Some are adapted to only temperate environments and others to more tropical environments. The Indian lines CS3541 and GPR-148 were crossed to several elite USA females and included in the trial which was designed to evaluate yield levels and stability across widely different environments. Some preliminary results from Weslaco, a sub-tropical location indicate that major differences in yield exist over the old standard hybrids.

Yield - Weslaco, Texas - 1980 (prelim)

RS610= 4567 lb/ac	ATx623 x CS3541=7600	A4R x GPR148=6933
ATx378 x RTx7000=4500	ATx625 x CS3541=7000	ATx623 x 77CS256(TS)=6867
ATx623 x RTx430= 7967	ATx623 x GPR148=6667	ATx623 x 76CS490=8100

Base metabolic temperatures (BMT) is the regression of time required to reach 50% of the potential germination across a range of temperatures. This BMT was presumed to be constant in sorghum and was indicated to be 10.5°C. However, critical evaluation has shown this BMT to vary from about 4.6 to over 16.0°C among different cultivars. BMT is a heritable trait and appears to be differently associated with temperate sorghums (high BMT) and tropically adapted temperate sorghums (low BMT). Several studies are underway with sorghums to determine if

selection of a particular range of BMT's contributed to particular climatic region adaptation.

Nighttime temperatures are substantially different during the sorghum growing season between South and North Texas. It is presumed that this difference in night temperature affects respiration and has an adverse effect on yield of grain. At Weslaco, in South Texas, where high night temperatures exist during the sorghum grain filling stage, Dr. R.A. Creelman has designed chambers that will use ambient daytime temperatures but will allow modifiaction of night temperatures. Sorghums that are well adapted to the temperate region (Lubbock, Texas, and Northward) will be compared to sorghums that are adapted to the more tropical areas of South Texas and Latin America. Growth and yield parameters will be measured to determine differences when the night temperatures are increased and decreased.

Three non-senscencing high yielding sorghum hybrids with different panicle characteristics were planted at College Station and Lubbock, Tx. to evaluate the sensitivity of seed size and seed number to plant population. The interactions will be determined using populations varying from 6,500 to 104,000 plants per acre. The three sorghums differ in genetic size and shape of their panicles. At College Station a split-plot designed experiment called for tillers to be removed from one section and allowed to develop on the other. At Lubbock tillers were not removed. Preliminary data show that head sizes on the low populations were extremely large and were reduced as population increased. Height increased with increasing population as did exsertion and lodging. The effects on components of yield have not been determined yet.

Perhaps one of the more important items coming from the project is the proposed release of two hybrids and an open-pollinated variety of sorghum jointly with the country of Guatemala. The hybrids, ATx623 x CS3541 and ATx623 x 77CS1, were identified from the TAT's evaluated in the country. The variety proposed for release is a selection from the cross (TX2536 x 72CS794-1) made in Guatemala from seed supplied from the Texas sorghum project. These three sorghums have established high yield levels, with stability, in Guatemala and should prove useful to several levels of agriculture in the area. Various food products have been made from the 3 proposed releases - cereal, baby food, tortillas and grits.

This project is closely cooperative with cereal chemistry, pathology, entomology and stress physiology.

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Sorghum Breeding - College Station
Texas A&M University

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September 15-19, 1980

INTSORMIL EXTERNAL REVIEW

PROJECT NO. XII TAM 1 INSTITUTION: Texas A&M University

PROJECT TITLE: Plant Breeding and Genetics - Productivity

PROJECT LEADER: F. R. Miller INVESTIGATOR: Page W. Morgan

OBJECTIVES: Determine how hormones regulate processes related to yield - primarily photoperiodism/thermoperiodism and sex expression.

BACKGROUND: We have preliminary evidence that application of plant hormones changes the photoperiod requirement for floral initiation in sorghum. We have detected a strong interaction between the photoperiod and thermoperiod. There is growing evidence that plant hormones regulate sex expression, and a wide range of sexual variants occur in sorghum including male sterile, female sterile, and apomictic lines. Clarifying the identity of the key hormones that are involved in photoperiodism/thermoperiodism and sex expression will allow plant breeders to more directly select for genes that will give the desired hormone complements.

APPROACH: We are analyzing the hormone complement in the collection of maturity genotypes that vary in four genes for photoperiod requirement. We are analyzing the growth behavior and flowering behavior of these genotypes under controlled conditions. In collaboration with Fred Miller and Roy Quinby, we are manipulating these and other genotypes in the field. A specific effort is being made to identify and analyze root hormones in collaboration with Wayne Jordan.

PROGRESS: We have found IAA and ABA levels higher in a late genotype (90M) than in an intermediate one (60M). In both genotypes we have obtained tentative evidence for a day-night rhythm in IAA, ABA and GA levels. We have found that shifting the thermoperiod forward in time out of phase with the photoperiod markedly hastens flowering. We are now growing the 11 maturity genotypes available in 10, 12, and 14 hour photoperiods. The 14 hour experiment is currently in progress and we are collecting data on flowering behavior and growth (leaf area, height, fresh and dry weight). Parallel experiments are being done at the three photoperiods with thermoperiods shifted in time; the 12 hour experiment has been done and the other two will follow soon. We have successfully manipulated height, tillering and, in the last year, flowering with hormone applications to plants in the field (joint work with F. R. Miller, R. Quinby and V. Isbell). We have improved our IAA isolation techniques with C^{14}-IAA as an internal standard. IAA and ABA are being collected to allow verification of identity with a mass spectrometer. Measurement of hormone levels in the other maturity genotypes will begin soon. We have obtained some additional funds for personnel and equipment. Orders have been placed for a high pressure liquid chromatograph with solvent programming, and Dr. James I. Durham will join the project as a research associate this month. He will assume primary responsibility for the hormone analyses. Graduate student J. Pao is doing the growth versus photoperiod/thermoperiod analyses, and she has been awarded a TAES research assistantship to support this work. Graduate student John Ambler is beginning isolation of cytokinins from root exudates of sorghum.

Project No.: XII TAM 2 (Sept. 15-19, 1980 Review)

Project Title: Breeding for Disease Resistance

Project Leader: Darrell T. Rosenow

Objectives:

1. Screen and evaluate sorghum germplasm for disease resistance.
2. Develop and release germplasm sources as lines and populations, and high yielding cultivars with resistance to such diseases as downy mildew, grain mold, anthracnose, head blight, head smut, leaf blight, rust, zonate, charcoal rot, and viruses.

Need for Work: The diseases mentioned above are all important in the developing countries. Screening for most can be done under natural conditions in Texas, where the environment is similar to the sub-humid tropical conditions present in many developing contries. The broad genetic base breeding program in Texas, the ability to select for high yield potential in tropical areas, and the natural occurrence of world-wide important diseases is an ideal situation in which to select simultaneously for disease resistance, high yield, and wide adaptation.

Approach:

1. Exotic lines, converted and partially converted lines and breeding materials are evaluated annually for resistance to internationally important diseases in a cooperative program with pathologists. Large disease screening nurseries at several locations in Texas under natural conditions are utilized, along with artificial inoculations whenever necessary or feasible. Also, some screening of selected items is done in Mississippi, Georgia, Puerto Rico, and selected overseas sites such as Mexico, Venezuela, and Brazil.
2. Elite sources of disease resistance are crossed and intercrossed with other sources and with agronomically elite lines to develop lines with higher levels of resistance, lines with multiple sources of resistance, and disease resistant, agronomically desirable lines. These breeding materials are selected and screened initially in large breeding-disease nurseries in Texas. Crosses for breeding and selection are made among new sources of disease resistance as they are identified from conversion and breeding materials. Disease resistant sources will be incorporated into random mating populations. The populations will be random mated, and selected within to increase levels of resistance. Crosses among lines will be evaluated in order to make a preliminary assessment of the inheritance of resistance. When disease resistant germplasm is identified, and as high yielding cultivars with high levels of disease resistance are developed, they will be released and distributed.

Results: Two large, disease screening-breeding type nurseries were planted cooperatively with pathologists in South Texas in 1980, where downy mildew and head smut infection was excellent. A large group of converted lines with excellent resistance to head smut and downy mildew were identified and the listings are being prepared. The dry season depressed development of grain mold and foliar diseases in South Texas this year. Other nurseries for virus and charcoal rot evaluation were planted at Lubbock. Charcoal rot resistance is closely related to the varietal response to post-flowering drought stress.

From previous disease resistance breeding, lines with resistance to downy mildew, head smut, grain mold, anthracnose, charcoal rot, MDM, rust, grey leaf spot, head blight, and leaf blight are ready for release.

Disease resistant materials are distributed upon request individually, and in nurseries such as the IDIN (International Disease and Insect Nursery). Also, some have been included in various ICRISAT nurseries.

SUMMARY of Project No. XII TAM 3 for External Review Panel, Sept. 15-19, 1980

PROJECT TITLE: Breeding for Insect Resistance

PROJECT LEADER: Jerry W. Johnson

NEED FOR WORK: Insect pests continue to compete with humans for the sorghum crop, especially in developing countries. Plant resistance is the simplest pest control practice to employ and requires a minimum of input by the farmer.

OBJECTIVE 1: OBTAIN GERMPLASM TO BE EVALUATED FOR RESISTANCE TO INSECTS

Approaches: Obtain germplasm from sorghum conversion program, plant introduction station, country programs, ICRISAT, commercial breeding programs, and US public programs.

Results: A midge test containing 90 entries was planted at six locations in the US and Mexico. Midge resistance was greater in material derived from IS 12666 and AF 28 than from other lines tested. The Coastal Bend of Texas still seems to be the best place to evaluate for midge resistance.

Nurseries and tests containing resistence to the greenbug were planted at three locations in the US and Brazil. Resistance to biotype E was identified.

OBJECTIVE 2: DETERMINE THE INHERITANCE OF INSECT RESISTANCE

Approaches: (1) Study the midge first. (2) Utilize the two most resistant sources available. (3) Cross with midge susceptible cultivars. (4) Cross R x R to determine if same gene(s). (5) Evaluate F_1, F_2, and F_3 generations.

Results: Crosses made in summer of 1980.

OBJECTIVE 3: DEVELOP AND RELEASE HIGH YIELDING, AGRONOMICALLY IMPROVED SORGHUM RESISTANT TO SELECTED INSECTS

Approaches: (1) Grow nurseries and tests at locations and times where the target insect should be present. (2) Select entries with the most desirable combinations of resistance and agronomic potential. (3) Develop "D" and "R" populations using resistant and non-resistant lines. (4) Cross resistant selections with agronomically elite disease resistant varieties. (5) Make crosses between resistant lines from different source cultivars.

Results: Nurseries containing 5,968 20-foot plots of F_2 populations, advance selections and checks were planted at each of three locations for midge resistance evaluation. Selections were made from 325 F_3 and F_4 rows; 1,204 selections were made in F_2 populations. Additional selections will be made in October 1980. Six hundred of the most promising F_2 selections are growing at Weslaco, TX to provide F_3 selections for evaluation in 1981. Advanced lines resistant to downy mildew, head smut, midge and with good yield potential were identified.

Sorghum resistant to biotype E greenbug were identified in field planting and verified with seedling greenhouse evaluations. Crosses were made to transfer biotype E resistance to improved agronomic types.

SUMMARY: Of Project No. XII TAM 4 for External Review Panel. Sept. 15-19, 1980.

PROJECT TITLE: Efficient Nutrient Use

PROJECT LEADER: Arthur B. Onken

INVESTIGATORS: Jerry W. Johnson

PROJECT OBJECTIVES: 1. Identify and define potential sources of more efficient plant nutrient extraction and/or utilization in sorghum. 2. Develop agronomically elite sorghums with improved nutrient use efficiencies. 3. Develop new methods for determining nutrient use efficiencies and to study responsible mechanisms when appropriate.

RESEARCH NEED: One of the major constraints to sorghum production in developing countries is low soil fertility coupled with little capital for fertilizer. Thus, increasing yields and maintaining yield stability by improvement of nutrient use efficiency through genetic changes is important.

RESEARCH APPROACH: Diverse cultivars of grain sorghum obtained from the breeding programs at Lubbock, Texas are being screened for N, P, and Fe use efficiencies in nutrient culture in greenhouse studies at Lubbock and field nurseries at Berclair and Lubbock. The first lines being screened are those that have shown promise in previous tests including nurseries in DC's. Crosses will be made among lines for preliminary assessment of heritability. Verification of selection will be made in the progeny of improved lines under field and solution culture screening.

SUMMARY OF SIGNIFICANT FINDINGS: Thirty-eight cultivars were planted in paired plots with B Tx 378 (susceptible check) in a nursery at Berclair, Texas in an area of known Fe deficiency. Ratings were made on the cultivars and B Tx 378 simultaneously and a paired plot analysis made. Fourteen cultivars were superior to B Tx 378 with B Tx 2761, GR-1-71-2-1, Tx 430 and IS 12666C (SC 175) being the top four. Greenhouse screening for Fe efficiency was initiated with ratings on twelve cultivars completed and twelve more currently being grown. Three cultivars were found to be superior to B Tx 378. These were: GR-1-71-2-1, Tx 430, and IS 2403C (SC 103). Some discrepancy was found between greenhouse and field responses indicating a need for further refinement of screening techniques. However, GR-1-71-2-1 and Tx 430 were in the top three cultivars in both tests showing that the screening techniques have validity. One hundred cultivars are being screened for N efficiency in a field nursery at Lubbock. Visual ratings are being made periodically and yield data will be taken. Twelve of these same cultivars are being screened in solution culture in the greenhouse for N efficiency in order that a comparison between the two screening techniques can be made.

INTSORMIL REVIEW

September 15 - 19, 1980

INSTITUTION: Texas A&M University PROJECT NO.: XII TAM 5

PROJECT TITLE: Plant Breeding and Improvement - Other Environmental Stress

PROJECT COORDINATOR: Page W. Morgan

INVESTIGATORS: Wayne R. Jordan, Lewis E. Clark, Jerry W. Johnson, and Darrell T. Rosenow.

PROJECT OBJECTIVES:

1. Determine the range of genotypic variability for characteristics which contribute to heat and drought resistance.

2. Define environmental conditions where these characteristics may contribute to superior performances.

3. Screen cultivars for adaptation to low soil moisture, high tolerance to temperature and moisture stress during panicle development, flowering and grain development.

4. Develop superior agronomic types with tolerances to these stresses.

APPROACHES:

A combination of approaches are used to define responses to heat and moisture stress at different growth stages, screen lines for quantitative responses, select for superior response, and finally produce lines and/or hybrids with enhanced resistance to these stresses. Specific activities during the past year include:

1. Establishment of nurseries to evaluate phenotypic response to early and late stresses at several locations.

2. Evaluation of physiological and morphological traits contributing to heat and drought resistance.

3. Genetic combination of lines with superior traits followed by evaluation and additional selection.

RESULTS:

1. Responses to early and late season stresses.

Stress nurseries are established at Lubbock, Chillicothe, Halfway and Big Spring, and variations in planting dates and watering are used to create desired early and late stress situations. Yield data and other agronomic information are collected as well to provide a means to refine the stress rating system and assure selection of desirable agronomic types.

Approximately 800 F_3 head rows selected from 60 F_2 populations at Chillicothe in 1979 are being evaluated in one early and two late plantings at Chillicothe. Additionally, about 2000 F_3 selections from Lubbock, Halfway, and Big Spring are being grown at Chillicothe for evaluation and selection.

2. Evaluation of drought resistance traits.

Approximately 150 converted lines were screened at anthesis for heat tolerance, desiccation tolerance and leaf wax load under dryland conditions in Temple. Rooting and soil water extraction patterns of 10 entries consisting of parents and hybrids were measured throughout the season in the final year of a 4-year study to assess the value of deep roots in drought resistance. Drought resistance traits are being compared with visual stress ratings in one study consisting of crosses of 5 female with 6 male parents planted at Lubbock, Big Spring, Temple, and Chillicothe. Parental lines were selected based on prior stress evaluations to provide a range of stress responses.

3. Cooperative studies with other states.

Over 50 lines and hybrids selected in Texas as possessing drought tolerance traits are being evaluated this summer for drought response using line-source sprinkler irrigation systems at Yuma, Arizona and Garden City, Kansas, and under dryland field conditions in Nebraska. Data from these additional sites should enhance our overall drought evaluation procedures.

INTSORMIL ANNUAL REVIEW

September 15, 1980

INSTITUTION: Texas A&M University PROJECT NO. XII TAM 6

PROJECT TITLE: Reproductive Systems

PROJECT LEADER: Keith F. Schertz

INVESTIGATORS: Roberta Smith

PROJECT OBJECTIVES:

1. Identify lines with superior reproductive characteristics including obligate apomixis and new cytoplasmic sterility systems.

2. Achieve anther culture and obtain haploid and homozygous diploid plants.

OBJECTIVE 1

Apomixis, asexual seed production, can be used to develop true-breeding hybrids. The use of apomixis in sorghum would eliminate the need for crossing each time a hybrid is produced. Hybrid vigor could be perpetuated indefinitely. We have made progress in identifying lines with apomixis but the frequency of apomictic seed production needs improvement. Apomictic lines are identified by embryo-sac analysis and the frequency of apomictic seed formation is determined in test-cross progeny. Lines studied have included cultivars, introduced lines, and lines isolated as potential apomicts by J. R. Quinby of Pioneer.

We have identified five sorghum lines with facultative apomixis and are attempting to derive lines with higher frequencies. To do so, a population has been formed of these lines and R473, the line reported from India to be apomictic. Other sources of apomixis are being sought among weedy sorghums including johnsongrass and shattercane in the U.S.A., and in collections of weedy species made by M. Andrew of Australia and K. E. Prasada Rao of ICRISAT who have agreed to cooperate in this study.

Cytoplasmic-genic sterility is essential for the production of current sorghum hybrids. Nearly all of the male-steriles and the hybrids produced on them have the same milo cytoplasm. This uniformity of cytoplasm is potentially hazardous. Our studies have revealed several sterile-inducing cytoplasms that may be used to diversify sorghum germplasm. Reciprocal crosses were made among converted lines and the steriles we derived as well as those found by others are being test-crossed. Those of most interest are being evaluated by mitochondrial DNA fractionation.

Twenty-six cytoplasmic-genic steriles have been isolated and test-cross results indicate that several of the cytoplasms have major differences from milo cytoplasm and among themselves. Final analyses await

the development of isocytoplasmic lines. D. T. Rosenow is sterilizing present parents in these new cytoplasms. Less distinctive differences were found among the KS lines released by W. M. Ross and he, Rosenow, and I are evaluating critical test-cross progenies of those steriles.

We have had the continual cooperation of Pioneer and cooperative research has been established with Dr. Pring of Florida for mitochondrial analyses of the most interesting cytoplasms. The mitochondrial DNA fractionation studies have in most cases corroborated our findings from test-cross progenies.

A diversity of cytoplasms for male steriles is coming from this project; these cytoplasms will also permit a greater nuclear diversity among female parents than is now possible.

OBJECTIVE 2

Anther culture for the derivation of homozygous diploids could improve the efficiency of sorghum breeding. It could provide the opportunity to select desirable new genotypes from very large populations of cells and from them to produce homozygous diploid lines in minimal time.

Anthers from field-grown lines were cultured to determine conditions which would cause the immature pollen to develop into haploid callus or plants. Chilling treatments of 8, 10, 12, and 14 C for 1/2, 1, 2, 4, and 8 days prior to culture were imposed. Over 3,000 anthers were cultured and results were variable in all treatments with phenolic discoloration and death being the major response. An anther in the control treatment did develop callus and produced a root which later died. Caffeine incorporated into the medium inhibited phenolic production and the anthers remained yellow; however, no callus development was observed. Culturing isolated microspores from which anther walls have been removed, as well as culturing entire spikelets are currently being tested. The former is showing some promise. It is anticipated that anther culture, if perfected in sorghum, could be used with mutation induction for characters not now readily available or isolated in the species.

INTSORMIL REVIEW

September 15-19, 1980

INSTITUTION: Texas A&M University PROJECT NO. XII TAM 7

PROJECT TITLE: Identifecation, evaluation, and implementation of effective systems for controlling diseases or pathogens in sorghum and millet.

PROJECT LEADER: R.A. Frederiksen

INVESTIGATORS: R.A. Frederiksen, J. Craig, R. Toler, G. Odvody, L. Castor, M. Pastor, M. Natural, S. Shabani, D. Franklin, D. Collins, Mary Howell, Greg Forbes, G. Wall

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 plai disease.

RESEARCH APPROACHES:

To develop superior host resistance to the major sorghum diseases, we have established a network of sorghum disease nursery sit.s based on the disease problems encountered in South Texas, College Station, and the High Plains. These disease nurseries were developed because of the high probability that they may be used to evaluate the reaction of hybrids, elite lines, experimental lines, newly introduced germplasm, and breeding material for disease reaction. As an integral part of this program elite germplasm is challenged in uniform nurseries worldwide for the responses to high pathogen populations providing us with an estimate of patnogen variability or their shifts in pathogenicity as well as the stability of nost resistance. We frequently augment naturally occuring disease by inoculation with selected isolates of test organism in both field and laboratory experiments. Finally, this project attempts to anticipate the critical factor associated with potential epidemics of sorghum diseases in order to better utilize or deploy host resistance. Thousands of disease susceptible entries are discarded each year.

RESULTS:

Excellent downy mildew, head smut and charcoal rot epidemics developed in our South Texas nurseries in 1980. Reactions of test entries for these diseases in 1980 will be among the most useful in our evaluations for host resistance under field conditions. Pathotype 2 of Peronosclerospora sorghi appears to differ only slightly from the original sorghum downy mildew patnogen and does not constitute a serious threat because, most of the DMR sorghums are resistant to patnotype 2. however, another new pathotype of P. sorghi discovered

this year may be much more important. This new isolate attacks Tx430, which is widely used as a commercial source of resistance to downy mildew. Trails comparing pathotypes 1, 2 & (3?) are currently under way in the laboratory at College Station. While no new or different races of head smut appeared, the prevalance of race 4 of Sporisorium reilianum (Sphacelotheca reiliana) continues to increase in the disease nurseries. Because of the low incidence of head smut in most of the commercially grown hybrids, the probability for another serious head smut epidemic appears low. Consequently, we are confident that our screening procedures have permitted the development of satisfactory resistance. The development of a head smut resistant sorghum population also appears quite promising. Experiments to obtain estimates of the rate of changes in pathogenicity for S. reilianum are nearly complete. Naturally occurring charcoal rot and lodging approached 100% in CSH6 (a susceptible Indian hybrid) whereas it was about 35%in ATx399 x Tx430, a popular South Texas hybrid and 0 lodging occurred in A35 x Tx430. These observations suggest that considerable progress has been made in developing lodging resistant hybrids under conditions favorable for charcoal rot.

Specific tissue colonization of sorghum by Colletotrichum graminicola appears to be influenced by environment. Consequently, the susceptibility of stalk, head or foliar tissue can be treated equally in evaluations and these tissue specific reactions are probably not conditioned by separate genes. Seed transmission of C. graminicola was demonstrated. Acremonium wilt (Acremonium strictum) developed at College Station in the bacterial stripe nursery. Vascular plugging and wilt in the upper portion of infected plants caused an average yield loss of about 60%. Lines such as Tx623, GPR148 and CS3541 are particularly susceptible under field conditions. Clearly, the Acremonium wilt in Texas differs from that in Egypt but is similar to the wilt observed in Venezula and Mexico. Progress was made in describing floral infection by grain mold fungi. Fusarium moniliforme infects glumes, lemma, palea and lodicules at anthesis. Mats of fungal hypae progressing acropetally develop between the ovary wall and the aleurone layer. A false black layer forms in some kernels 10 to 16 days earlier than normal resulting in smaller than normal kernels. This information, characteristic of the susceptable cultivar Tx2536, should provide a sound basis for evaluating resistance in other cultivars.

As a means to reduce the possible dissemination of pathogens with seed, a downy mildew free, seed certification procedure, was established in 1980. In Texas, this program is administered by the Texas Department of Agriculture. Yield losses in grain sorghum due to sorghum downy mildew are sensitive to plant population, disease reaction of the hybrid, and environmental conditions following planting.

INTSORMIL REVIEW SUMMARY

September, 1980

INSTITUTION: Texas A&M University PROJECT NO. XII TAM 8

PROJECT TITLE: Identification, evaluation, and implementation of effective systems for controlling diseases or pathogens in sorghum and millet. (Cultural Control)

PROJECT LEADER: Gary Odvody

INVESTIGATORS: G. N. Odvody, R. A. Frederiksen, L. Reyes, O. Ziv, C. Kempf

PROJECT OBJECTIVES: Explore the use of cultural, chemical, and biological control measures as an adjunct to control by disease resistance.

SUMMARY OF RESEARCH APPROACHES:

Cultural controls of plant diseases can provide the primary means of disease control when host resistance is lacking or difficult to assess or incorporate into agronomically desirable material. These controls can also be used to compliment existing host resistance and actually conserve the longevity of host resistance, especially if genetically variable pathogens are involved. However, in the advent of new pathotypes overcoming host resistance, available or "in use" cultural control alternatives are desirable for interim or long term control.

Our research largely involves the ecological study of major soilborne pathogens causing endemic and epidemic diseases of sorghum and millet and include exotic pathogens of potential quarantine significance. These ecological studies investigate host and environmental factors related to disease incidence and development. Knowledge of these factors and their assessment will implicate the most favorable approaches to cultural control of diseases and also lend insight into development of more effective host resistance screening techniques.

SUMMARY OF SIGNIFICANT FINDINGS AND ONGOING RESEARCH:

Field studies are investigating traditional cultural controls of sorghum downy mildew (SDM) including simulated crop rotation vs. sorghum monoculture, deep plowing (30 cm, 12 in) vs. conventional tillage (15-20 cm, 6-8 in), and use of trap crops. Both simulated crop rotation and deep plowing consistently demonstrated reduced incidence of SDM and a lower population of oospores in the critical 15-20 cm soil depth when compared to monoculture and conventionally-tilled plots, respectively. Trap crop experiments demonstrated reduced incidence of the disease in sorghum following host and non-host crops in greenhouse studies but field studies have been hindered by moisture shortages at planting times for both the trap and sorghum crops.

A systemic fungicide, metalaxyl, active against Pythiaceous fungi, gave near 100% control of SDM when utilized as a seed treatment at rates from 0.1 to 3.0 g a.i./kg seed. Plants from nontreated seed had 8-27% SDM and in many experiments had significantly reduced grain yields when compared to plants from metalaxyl-treated seeds. Seed from SDM-infected plants of three cultivars planted in noninfested soil with glumes attached and removed had 6 and 3% SDM-infected progeny plants, respectively, but similar seed treated with metalaxyl had 0% SDM. This suggests the value of metalaxyl in quarantine situations where SDM-seed infectivity is known or suspected.

The curative activity of metalaxyl will be evaluated on systemically infected SDM plants during the next growing season and other fungicides are being sought for evaluation in control of sorghum downy mildew.

Studies have been initiated on the population dynamics of SDM oospores in variable soils. Major factors investigated include oospore survival, dormancy and initial infection processes. Of initial importance in these studies is the development of an improved technique to quantitate oospores in soil and to isolate them free of soil contamination. A technique has been devised which recovers approximately 80-90% of the oospores from a 4 g soil sample within a 2 hour period.

This same isolation technique demonstrates promise for use in isolation and quantitation of other soilborne fungal propagules with densities less than the saturated sucrose solution used in the technique. Thus, it is anticipated that the population dynamics and inoculum potentials of head smut spores and charcoal rot sclerotia can be studied with this method.

Additional charcoal rot studies have assessed alternative field inoculation techniques but none were superior to standard stalk inoculations. Further studies of host-pathogen-environment interactions are being pursued with charcoal rot under field and controlled environmental conditions in attempts to develop improved cultural control and germplasm screening techniques.

Seedling disease-root rot-stalk rot complexes in sorghum are being investigated with particular emphasis on a Pythium root rot complex in North Texas. Metalaxyl fungicide is being utilized to help assess the role of this pathogen in the complex. Studies of water relations and initial infection processes with this pathogen are also being pursued.

Bacterial spot of pearl millet caused by Pseudomonas syringae was observed on field materials at Lubbock, Texas, in 1979. This was the first recorded observance of this disease since its original description in Iowa in 1926. Resistance was predominant in field observations and greenhouse tests but some materials possessed high susceptibility. Further identification of susceptible cultivars through greenhouse and field testing and field surveys is anticipated.

INTSORMIL REVIEW

September 15-18, 1980

INSTITUTION: Texas A&M University Project No. XII .AM 9

PROJECT TITLE: Identification, evaluation, and implementation of effective systems for controlling diseases or pathogens in sorghum and millet.

PROJECT LEADER: Robert W. Toler

PROJECT OBJECTIVES:

Develop critical disease diagnostic systems.

RESEARCH APPROACHES

Make a collection of sorghum germplasm that shows differential reactions to different viruses and to strains of viruses that attack sorghum. Determine specific reactions and develop a collection to aid in sorghum virus and strain diagnosis. Build an anti-serum bank for sorghum viruses to use with serologically specific electron microscopy for sorghum virus disease diagnosis. Determine if pinwheel inclusions can be used as a diagnosistic tool in identification of maize dwarf mosaic virus and sugarcane mosaic virus strains.

RESULTS

We have made and still are adding to our collection of sorghum germplasm that shows differential reactions to different viruses and strains. The International Sorghum Virus Nursery has been put together and includes 10 materials from the U.S. and Australia. This nursery was distributed world wide in 1979 and 1980.

In order to use a critical diagnostic virus system involving ultrastructure of cells, serology of crude and purified virus extracts as well as Serologically Specific Electron Microscopy, a large number of antiserum are needed. Ultimately antiserum is needed to all the viruses and strains that attack sorghum. We have recently made a large quantity of antiserum to MDMV-B and are in the process of building antiserum to MDMV-D,E and F. Pinwheel inclusions are distinctive in the potato virus Y group that includes the Sugarcane Mosaic and Maize Dwarf Mosaic viruses. We are studying these inclusions to determine if they may be used to separate and characterize the MDMV and Sugarcane Mosaic Virus (SCMV) strains. To date the pinwheel inclusions could not be distinguished in MDMV strains A, B, D, E, or F. We are currently looking at the pinwheels from the SCMV strains.

During 1980 the sorghum differential nurseries were grown in cooperation with Dr. M. Riccelli in Venezuela where virus reaction on MDMV-A resistant lines was severe. Data and plant material was collected in Venezuela in the third week of August 1980. The virus and pinwheel inclusions were found in disease tissue of BTX430 and Johnsongrass but not in QL3 Texas or India seed source or QL11 Australia seed source. Serologically the virus was related to SCMV-A, SCMV-H and MDMV-A. Using serologically specific electron microscopy the virus was found to be more closely related to SCMV-A group (ABD) than SCMV-H or MDMV. However, the virus is transmitted to Johnsongrass. Sugarcane strains do not normally go to Johnsongrass. Based on the reaction of differential breeding lines the virus is related to MDMV but different from previously reported strains. The primary variation is in the reaction of sorghum with resistance of MDMV-A in Venezuela. Materials that mosaic only in the U.S. necrose when infected by the Venezuela virus. These include: Tx430, Tx2536, Tx2752, Tx2737 among others. However, we failed to find the Venezuela virus infecting QL 3 or QL 11 which are also immune to MDMV-A and previously reported as susceptible in Venezuela. The virus found in Venezuela belongs to the sugarcane mosaic virus classification and in the Maize Dwarf Mosaic Virus group since it goes to Johnsongrass. The virus should be known as Maize Dwarf Mosaic Virus strain V for Venezuela.

In 1979 plants were found with a vascular wilt at Plainview, Texas. The pathogen was diagnosed as Acremonium strictum W. Gams. The leaves and sheaths become infected and the pathogen moves through the vascular tissue. Susceptible lines include BTX622, BTX623, BTX624, and SC170-6 in the field. Lines found susceptible in the greenhouse include IS12553C, TX2078, TAM428, TAM2561, IS12664C, and TX2536. Diagnosis of Acremonium wilt was made in Venezuela in August 1980. The plants had typical vascular browning and wilting.

Department of PLANT SCIENCES

Instruction — Research — Extension

Genetics
Plant Pathology
Plant Physiology

TEXAS A&M UNIVERSITY

COLLEGE OF AGRICULTURE

COLLEGE STATION, TEXAS 77843

713-845-7311

Zeng

Project Title: Nature of Resistance to Diseases XII TAM10

Project Leader: J. Craig
USDA/SEA, College Station, TX

Project Objectives:

1. Determine mechanisms of disease resistance

2. Determine mode of inheritance of disease resistance

3. Determine variability for virulence among pathogen biotypes

These objectives will provide the information needed for efficient utilization of diverse types of disease resistance in sorghum improvement and will assess and reduce the vulnerability of sorghum to heterogenous pathogen populations.

Project Approaches:

Histological studies of relationships between host and parasite are used to identify the manners in which resistance to grain mold and resistance to sorghum downy mildew (SDM) are expressed. Appropriate populations derived from crosses of resistant and susceptible sorghum genotypes are being tested to determine the mode of inheritance of resistance to SDM. Field surveys and greenhouse tests are conducted to identify new pathotypes of SDM.

Project Results and Future Plans:

Studies of grain mold found that factors conferring resistance to mold are located in the epidermis of the seed coat. Histological observations of SDM indicated that susceptibility was determined by both the rate at which the pathogen progresses in host tissue and the rate at which the host plant develops. Two new pathotypes of sorghum downy mildew were identified by their ability to attack sorghum genotypes previously resistant to SDM in Texas.

Histological studies of compatible and incompatible host and parasite relationships are continuing. The F_2 and F_3 generations of crosses of resistant with susceptible genotypes will be tested for reaction to SDM. Field surveys for new pathotypes of SDM are continuing. A search for horizontal types of resistance to SDM will be initiated. The survey for new pathotypes in Texas will continue cooperative relationships with similar programs in Egypt (PL480 Sorghum Disease Project) and at ICRISAT in India.

INTSORMIL PROJECT REPORT

George L. Teetes
(Texas A&M University)

Project title: Development and evaluation of systems for controlling insect pests of sorghum by integration of resistant varieties, cultural manipulation and biological control.

Project objective XII TAM 11: To identify and evaluate sorghums resistant to insects, determine resistance mechanisms, investigate plant-pest ecological responses and determine economic injury levels.

Work plan objectives:

1. Screen converted exotic lines for sorghum midge resistance.
2. Screen agronomically improved breeding lines and hybrids for sorghum midge resistance.
3. Resistance mechanisms studied to identify levels of nonpreference, antibiosis and tolerance.
4. Compare midge densities to plant damage and subsequent yield.
5. Compare densities of four species of panicle infesting bugs to grain yield and yield loss.

Project objective XII TAM 13: To determine the biology, systematics, behavior and seasonal abundance profiles of sorghum insect pests and associated predators and parasites as support tactics in pest control schemes.

Work plan objectives:

1. Monitor the seasonal abundance of sorghum midge and the incidence of diapause and parasitism in johnsongrass and sorghum.
2. Investigate factors influencing diapause termination of sorghum midge in field and laboratory studies.
3. Determine seasonal midge generation duration, adult longevity, progeny, production, natural mortality, and sex ratio.
4. Investigate midge adult behavior and factors that influence adult emergence. oviposition, mating, and movement.
5. Determine the nature of midge parasitism and parasite biology.

International involvement:

1. Preparation of training materials and activities.
   a. FAO plant production and protection manual-"Elements of Integrated control of Sorghum Pests."
   b. In cooperation with ICRISAT-"Sorghum Insect Identification Handbook."
   c. Planning committee for symposium-"Sorghum in the 80's."
2. Information exchange
   a. Guidance in screening sorghums for insect resistance to researchers in Mexico, Honduras and India.
   b. Reprints and written reports to LDC researchers.
   c. Liaison between LDC entomologists and U.S.A. plant breeders.
   d. LDC and international visitors.

Cooperative work:

1. Project objective TAM 11 dealing with plant resistance is a joint venture with plant breeder Dr. Jerry W. Johnson. This relationship has been most effective as a result of blending expertise.
2. Project objective TAM 13 dealing with biology and ecology relates directly to Dr. Frank E. Gilstrap's objective on biological control and we share graduate students in this area.

Goal: To develop control strategies that have application to LDC's, and to gain enough knowledge about the insect pests and their natural enemies to explain how and why control strategies work and how they should be changed to fit specific condition

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NARRATIVE REPORT

Four project objectives relate to the project title for entomological research at Texas A&M University. I am responsible for two objectives that deal in general with plant resistance, and pest and natural enemy biological and ecological relationships. The overall goal is to develop control stratagies, especially insect resistant sorghums, and based on an understanding of and factors which influence pest biology and population dynamics, determine how the most effective control schemes function and how they could be manipulated to fit different conditions that exist in the U.S.A. and LDC's.

Much emphasis is placed on the sorghum midge because it is a cosmopolitan pest of great severity. Also, changes to improved sorghums in an LDC frequently intensify midge problems. Other insect/mite pests are dealt with, especially in regard to screening for resistance, economic injury levels, biologies and control measures in the context of managing key pests.

Concerning the plant resistance objective, 213 converted exotic lines were screened for sorghum midge resistance and 7 lines previously unreported as resistant were identified. Agronomically improved lines and hybrids, with midge resistance derived from TAM 2566 (SC 175-9), AF 28 and TP6BD were screened. Improved midge resistant parental lines have been developed. Both parents must be resistant. Resistance mechanisms in lines are antibiosis (result of larval mortality) and nonpreference (less adult visitation). Faster rates of anthesis and ovary development appear to be associated resistance mechanisms. Resistance can be overcome at extremely high midge densities (200-400 midge/panicle/day). The reason for this is unknown, but will be studied. Observations indicate that resistant sorghums will withstand 10 midge/panicle/day while susceptible sorghums are damaged at 1 midge/panicle/day during flowering.

Research completed this year involved screening sorghum grain for maize weevil resistance. Among 169 tested converted lines, SC006, 0224, 0226, 0233, 0311, and 0331 appeared to possess grain resistant to this stored grain pest. Factors which reduced grain damage by the weevil were size (small), endosperm (corneous), and hardness (hard).

Damage to sorghum by rice, southern green and Conchuela stink bugs and leaf-footed bug was assessed. Economic injury levels will be established from the data collected during the last three years.

The objective dealing with biology, behavior and seasonal abundance profiles is designed to obtain data that describes midge population dynamics and factors that influence it. The abundance of sorghum midge and the incidence of diapause and parasitism were monitored seasonally in johnsongrass and sorghum along with temperature, relative humidity and rainfall. The data are collected to describe midge population dynamics and to identify factors that result in midge density increase or decline. Midge spend the winter in diapause and spring emerging adults initiate infestations. It is critical that factors which influence diapause termination be understood as the first step in predicting midge abundance trends. Temperature and moisture are the most important factors relating to the incidence of diapause and its termination. More data are needed on overwintering survival and host availability. Along with descriptive abundance data, the influence of specific life habits of the midge are determined and these are related to population dynamics. Consequently, we are measuring generation duration, adult longevity, progeny production, mortality and sex ratio, and factors which influence these. Likewise, determination is made of factors which influence adult emergence from infested panicles, oviposition, mating and movement. Since four species of midge parasites influence midge density, the nature of parasitism and parasite biology is studied.

Ultimately, the data collected will be used in computer simulation models that will enable us to devise management strategies that revolve around midge resistant sorghums.

INTSORMIL PROJECT REPORT

Frank E. Gilstrap
(Texas A&M University)

Project title: Development and evaluation of systems for controlling insect pests of sorghum by integration of resistant varieties, cultural manipulation and biological control.

Project objective XII TAM 12: To identify and evaluate indigenous and/or exotic natural enemies of sorghum midge, greenbug, Banks grass mite, and several lepidopterous pest species as potential control agents.

Work plan objectives:

1. Synthesize literature on natural enemies of sorghum midge and sorghum infesting aphids.
2. Investigate sorghum midge parasite phenology and abundance on alternate host plants in selected locations.
3. Survey extant parasite fauna attacking greenbug on sorghum in all sorghum producing areas of Texas.
4. Study natural enemies of greenbug in sorghum and alternate host systems, releasing new, exotic natural enemies for establishment when feasible.

International involvement:
Contributed to preparation of FAO plant production and protection manual entitled "Elements of Integrated Control of Sorghum Pests," preparing the chapter entitled, "Biological Control of Sorghum Insect Pests."

Cooperative work:
Several objectives of XII TAM 12 relate directly to objectives of XII TAM XII TAM 13 under the direction of Dr. George L. Teetes, and we share graduate students as well as maintain close interaction to coordinate research activities.

Goal:
To develop understanding and concepts for application of biological controls in pest management programs in LDC's.

NARRATIVE REPORT

The major objective of XII TAM 12 is to identify and quantitatively evaluate natural enemies of major pests of sorghum with the ultimate goal of knowing how to manipulate efficacious natural enemies by augmentation, conservation, or importation for pest suppression in the U.S.A. and LDC's. Because of the ephemeral nature of sorghum, the key to biological control of sorghum pests is understanding their population dynamics in component parts of the 12-month ecosystem. Thus, emphasis must be placed on alternate hosts and their actual and potential contributions to natural enemy populations in sorghum as a crop.

Initial efforts of XII TAM 12 have been identification of natural enemies, both in the U.S.A. and in the rest of the world. In this regard, a major review of natural enemies of sorghum pests of the world has been completed and published

by FAO in 1980. This review, a chapter in "Elements of Integrated Control of Sorghum Pests," summarized geographic distributions for 27 pests of sorghum, the host plants they are associated with, and the known geographic distributions of natural enemies reported for each pest. The review evidenced the fact that generally very few natural enemies have been reported from LDC's, some of which are in the probable center of origin of the Sorghum genus, and that this is most likely due to lack of attention. Much should be done in LDC's to rectify this lack of knowledge, identify and determine distributions for natural enemies of each pest, and then to redistribute efficacious natural enemies to parts of the world where they can contribute substantially to pest suppression.

Field research for XII TAM 12 has centered on identification and characterization of natural enemies of sorghum pests in Texas. Natural enemies of sorghum midge have been collected from all parts of the state. Results from these studies to date are: more than 15,000 heads of Sorghum halepense were collected and are now being processed; at least 4 parasite species were collected, though not necessarily from all parts of the state; S. halepense suitability to support development of midge and midge parasites seems empirically better related to physiological than chronological age of seeds. From these collections we will identify parasites of midge and determine their distributions in Texas with the eventual goal of obtaining midge natural enemies from other parts of the world for importation and release. Research is also underway to study midge and midge parasite population dynamics on S. halepense, a key alternate host of midge in Texas, in locations not obviously influenced by cultivated grain sorghum. These studies will reveal aspects of the natural interactions between midge and its parasites and also contribute to methodology for efficient collection of midge parasites, both of which are essential to better utilization of biological controls of sorghum midge.

The second field research aspect of XII TAM 12 is centered on greenbug. As has been done for midge, natural enemies of greenbug have been collected from all parts of Texas. These data will serve as a baseline for interpretation of results from releases of exotic greenbug parasites. The greenbug biological control program is already in the importation and release phase. Most prior parasite releases have been made in the panhandle area of Texas and in Oklahoma and usually were made on summer infestations of grain sorghum. We are expanding the program to include releases in central and south Texas where weather extremes are more moderate and chances are better for establishment on winter populations of greenbug on winter wheat. Once established, these parasites should then contribute to greenbug control in all parts of the state, even in parts where the parasites cannot normally overwinter. A second aspect of the greenbug research is study of greenbug parasite dynamics on alternate hosts, especially winter wheat. These studies should provide understanding of winter host contributions to greenbug biological controls on sorghum in the summer months. Results from greenbug studies to date: more than 10,000 mummified greenbugs were collected and are currently being evaluated for diagnostic characteristics peculiar to the attacking parasites; none of the several exotic parasites released in earlier phases of the program has yet been recovered from our samples; we have 1 species of parasite in culture and expect to obtain several more species before Janurary, 1981. Releases of exotic parasite species will be started in late fall or early winter months.

INTSORMIL PROJECT REPORT

George L. Teetes
(Texas A&M University)

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TEXAS A&M UNIVERSITY
DEPARTMENT OF ENTOMOLOGY
COLLEGE STATION, TEXAS 77843
AC 713-845-2516

1980 INTSORMIL REVIEW

PROJECT NOS: XII TAM 11-14

TITLE: Development and Evaluation of Systems for Controlling Insect Pests of Sorghum by Integration of Resistant Varieties, Cultural Manipulation, and Biological Control

INVESTIGATORS: George L. Teetes
Kerry F. Harris
Frank F. Gilstrap

PROJECT NO: XII TAM 14; Kerry F. Harris, Investigator

OBJECTIVE: Define Insect Vector-Virus-Host Plant Interactions

APPROACHES: Establish Virus-Vector Laboratory

Study MCDV- and MDM-Vector Interactions

Research Vector-Plant Interactions
- Vector Probing and Feeding Behavior
- Morphologies of Vectors' Feeding Apparatuses
- Interactions of MCDV and Plant Host

Relationships of Vectors' Behavioral Patterns to Transmissions

Monitoring of Alate Aphid Vector Populations

RESULTS: Establishment of Fully Functional Virus-Vector Laboratory

Analyses of Various Ultrastructural Studies on the Morphologies of Vectors' Feeding Apparatuses are Revealing Hitherto Unreported Receptor Organs in Vectors' Sensory Transduction System

Development of Two Very Promising Systems for Direct Observation of Leafhopper Probing and Feeding Behavior

Accumulation of Data on MCDV-Plant Interactions at the Tissue, Cellular, and Subcellular Level

Defining of Virus-Vector Interactions for Maize Chlorotic Dwarf Virus and the Black-Faced Leafhopper, *Graminella nigrifrons*

Establishment of Maize Dwarf Mosaic Virus Research Objectives

Beginnings of Aphid Vector Monitoring Program

Establishment of International Ties

Submitted by
K. F. Harris
Kerry F. Harris
September 17, 1980

INTSORMIL Review
September 14, 1980
Lubbock, Texas

Institution: Texas A&M University Project Number: XII TAM 15

Project Title: Food and Nutritional Quality of Sorghum

Project Leader: Lloyd W. Rooney, Cereal Quality Lab, Soil & Crop Sciences Dept., College Station.

Project Objectives: Brief Statement

1) Determine how sorghums are processed and consumed in traditional village foods and evaluate the grain characteristics that affect quality for traditional products.

2) Develop simple, practical lab 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 factors that affect resistance to grain molds and devise lab procedures to detect genotypes with resistance.

Goal: The ultimate goal of this project is to define the quality attributes of sorghum for use in the major food products in which sorghum is used. The products emphasized in our lab are tortillas and Tô made with acid, alkali and neutral cooking conditions. We have done research on ogi, roti and rice-like products in the past. However, we are concentrating our efforts because other labs are interested in rotis. Once the attributes are defined, simple tests can be devised to use in selecting for sorghums with required properties. A wide array of simple tests will probably be required. Finally, when an advanced line looks promising, the final test will be to confirm that it has high quality by conducting local cooking trials in villages. As for all cereals, the final quality test must be actual product testing by the consumer.

The wise use of simple prediction tests to evaluate and screen breeding material will increase the efficiency of the entire crop program and should preclude development of poor quality sorghums. Thus, Drs. Pattanayak and Scheuring in Haute Volta and Mali will not need to conduct cooking trials to evaluate breeding material

Another goal is to develop an understanding of sorghum quality so that its nutritional value and organoleptic properties can be improved by breeding or by use of improved, practical processing methods.

Determination and Evaluation of Traditional Methods of Producing Sorghum Foods

(Objective 1) Field investigations in Mali and H. Volta, travel to India and Mexico and participation in International Sorghum Food Quality Trials have led to a much better understanding of the attributes of sorghum that may be important in production of various sorghum foods. The specific knowledge of detailed village processes has led to more effective utilization of graduate students and students wives to develop standardized lab procedures for various kinds of Tô - acid, alkali and neutral; tortillas and ogi.

The International Food Quality Trials were developed in 1978 by ICRISAT with our help to find a way to determine how grain attributes differ for the major food products. Thus, samples of grain grown in the rabi at ICRISAT were sent by Dr. D.S. Murty to 8 to 10 collaborators for evaluation, analyses, etc., by each collaborator for the product indigenous to their country. The use of a common set of samples permits a better definition of quality attributes for given products.

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For example, sorghums that produce good rotis will probably produce excellent tortillas, also. Information on sorghum Tô made with acid and alkali suggests the quality of sorghum differs for acid and alkali Tô. Another benefit from this study is that peronnel around the world have gained experience in attempting to standardize methods. Thus, the data being collected in 1980 will be more accurate and more useful. Our role in the tests has been to serve as one of the collaborators and to assist in the design and analysis of the data. Collaborators are:

COLLABORATORS	FOOD PRODUCTS	COUNTRY
A. Ireugas Evaristo and V. Guiragossian	Tortillas	Mexico
J. Scheuring	Tô (alkaline)	Mali
S. Da and C. Pattanayak	Tô (acid)	Haute Volta
S. Mukuru	Ugali	Tanzania
M. Bolling	Bogabe	Botswana
B. Gebrekidan	Injera	Ethiopia
H. Perten and S. Badi	Kisra	Sudan
D. Murty and R. Jambunathan	Roti, ugi and ugali	India
L. Rooney	Tô, tortillas	U.S.

Tortillas

Procedures: Micro (50g samples) and macro (100 and 1000g samples) procedures for preparation of corn and sorghum tortillas have been standardized and applied to sorghum samples representing widely different germ plasm with emphasis on sorghums with a white or colorless pericarp, without a testa and with a low incidence of staining from glumes. Tortilla color is the first limitation preventing sorghum use in tortillas. Other factors exist, but color dominates. Sorghums with colored pericarp are undesirable for tortilla production. Variation among the white sorghums is great with the native sorghums of Central America, producing the lightest colored tortillas. Some experimental lines look good in tortillas. Environmental conditions during grain maturation and prior to harvest affect color of tortillas made from white sorghums drastically. Weathered sorghum gives off-colored tortillas.

Cooking time and dry matter losses: 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 corneous sorghums require the most. Sorghum requires less alkali, shorter cooking and steeping times than corn and dry matter losses during optimum cooking and steeping of corn and sorghum are the same. In some experiments, a citric acid wash reduced the pH of the sorghum nixtamal and reduced the color of the tortillas. Use of steel grinders increases color drastically probably because of polyphenol-iron complex formation. Methods to measure color, texture and keeping properties of tortillas have been developed to provide objective techniques to use in determining the factors affecting tortilla production.

Simple prediction methods: An alkali test has been developed and used to select white kernels of sorghum with the least color. Several kernels of sorghum are placed in standard alkali for two hours and the color of the kernel and solution is subjectively rated on a 1-4 basis in comparison with standard samples. The test has been used in screening the food grain population. Its real value must still be determined, but it appears to be a better than usual evaluation of the grain.

An extrusion cell has been built for use with the Instron to permit measurement of the texture of cooked sorghum. This method can be used to measure the optimum cooking time of sorghums. The method has been used to measure the tex-

ture of 85 sorghum samples cooked and soaked under a fixed procedure to provide a data base for developing a procedure to predict optimum cooking time.

Water absorption, increase in cooked kernel weight and cooking of a few kernels in dilute alkali are tests of potential value.

Corn-sorghum blends: Blends of masa from U.S. commercial white sorghum hybrids and white corn were found to produce acceptable tortillas up to 40% sorghum - 60% corn ratios. All of our comparisons have been with white corn. When yellow corn is the standard, much higher levels of sorghum can be incorporated. These findings have been documented by Dr. Ireugas, INIA, Mexico City.

Simple processing innovations: Sorghums that have been pearled to remove the pericarp can be made into high quality tortillas that compare with white corn. Even commercial sorghums produce tortillas of edible quality. Blends of pearled sorghum and corn produce highly acceptable tortillas.

Ground, micronized pearled sorghum has been used as a substitute and in blends with Masa Harina (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.

Improved varieties and better processing techniques: The combination of better sorghum varieties with simple processing techniques to improve sorghum and sorghum-corn tortillas could lead to a better acceptance of sorghum as human food in Central America. This concept should be evaluated in village trials. The social and physicological factors affecting use of sorghum are major factors.

Collaboration: Collaboration between our efforts and Dr. Ireugas' lab in Mexico has been initiated. Samples of grain grown by Dr. Guiragossian, ICRISAT, Mexico have been obtained. Dr. Futrell, Mississippi State University, wants to conduct field research in Central America which could permit trials to evaluate acceptability of improved sorghum tortillas. Two graduate students from Mexico have significantly aided our research on tortillas. Samples of sorghum and information have been exchanged with Honduras and Guatemala. I have been disappointed with our inability to develop strong linkages in Central America.

Tô (Stiff Porridge Food)

Semi-micro and macro methods: Laboratory milling procedures for producing Tô flour and for cooking Tô in acid, alkali or neutral pH have been standardized. The laboratory milling procedure uses an inexpensive barley pearler to dehull the grain. The dehulled kernels are ground in a laboratory mill to produce flour. The procedures were developed to give yields of product with specifications as close as possible to those obtained by traditional hand pounding procedures. Grain samples obtained from Haute Volta and Mali were used to develop the milling procedures in our lab. Our products were compared directly to milled products from the same grains (sublots) that were traditionally milled in Mali and H. Volta.

These lab methods are being used to evaluate subsamples of grain from the West African ICRISAT trials which have been evaluated by Dr. Scheuring. Thus, grain of known quality can be compared using our methods.

Basic studies: Promising methods to determine properties of Tô include the Instron, a penetrometer and a stickiness test using an old double pan balance. We are evaluating several gel spread tests; a spread test developed by Murty (ICRISAT) looks promising. Amylose content does not explain the differences in Tô quality among sorghums. Detailed characterization of starch and endosperm fractions continues to determine why sorghums differ in Tô making properties.

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Storage time, temperature and pH of the lô affects keeping properties of Tô. Flour age may affect Tô quality also as well as the environmental conditions under which the grain matures. Studies continue to sort out some of these contradictory findings.

Nutritional value of Tô: The "in vitro" starch and protein digestibility of Tô made with acid, alkali and neutral pH were not significantly different from each other for both freeze dried and oven dried Tô's. The digestibility of starch and protein was greatly increased by the Tô preparation procedures compared to the flour. A multiple enzyme technique will be used to determine the effects of method of Tô preparation on sorghums with low, medium and high tannin. The effect of Tô preparation on phytin content will be measured.

Effect of kernel characteristics on Tô: Sorghum varieties with good and poor Tô quality have been crossed, increased and progeny will be evaluated using the micro lab Tô procedure. The crosses have been made to permit evaluation of pericarp color, plant color, and other characteristics.

Nutritional Value

The in vitro digestibility of sorghums with waxy and nonwaxy endosperm taken from segregating populations and sister lines indicated that waxy had significantly improved starch digestibility and slightly better protein digestibility. However, the waxy sorghums had lower kernel weight than the nonwaxy sorghums. For 15 comparisons between waxy and nonwaxy, three waxy sorghums had higher starch and protein digestibility values than the nonwaxy counterpart with equal kernel weights. It may be possible if this is true to find sorghums with improved digestibility. However, it may prove an uphill battle because they probably will be highly susceptible to molds.

Swine feeding trials conducted by Tanksley and co-workers; in vitro, in vivo digestibility trials; light and SEM data obtained in our lab have all confirmed that waxy sorghums are more digestible than nonwaxy sorghums. These findings are interesting in light of recent reports by Graham and MacLean concerning the poor digestibility of sorghums for children. The food processing properties of waxy sorghums make undesirable tortilla, rotis, ogi and Tô. They might be preferred in China.

In vitro protein digestibility measured by two methods ranked sorghums with red and white pericarps without a testa highest, those with a testa (B_1-B_2-ss) were slightly lower while those with a testa and spreader (B_1-B_2-S-) were lowest. Considerable variability existed within each group. For example, some sorghums with a testa have values equal to those without a testa.

Kernel Structure, Mold and Weathering Resistance

Light and fluorescence microscopy has helped to determine the location of low molecular weight phenols in sorghum kernels with various genes for pericarp color. The type and quantity of the phenols will be related to mold and weathering resistance. Dr. Jon Faubion, new Assistant Professor in the Cereal Quality Lab, will lead this effort.

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