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PROJECT STATEMENT

A. Project Summary

1. Statistical

Project Title	Improvement of Grain Sorghum for Developing Countries (DCs)
New or Extension	Extension
Contractor	Texas A&M Agricultural Experiment Station
Principal Investigator	R. A. Frederiksen
Duration	March 1, 1977 - February 29, 1980
Funding by Fiscal Years	FY 77 - $290,000 FY 78 - 310,000 FY 79 - 350,000 Total $950,000
Prior Funding	Life-of-project total - $280,000 (FY 76 - $130,000)
Project Manager	Earl R. Leng, TA/AGR/CP

2. Narrative Summary

This is a proposal to conduct cooperative grain sorghum research aimed at development and dissemination of improved high yielding sorghum cultivars with resistance to disease and insect attacks. It is a follow-on activity to a current project with Texas A&M which is scheduled to terminate February 28, 1977.

The project will build on experience and findings of the current project (contract AID-ta-c-1092), with an expanded scope of work and level of effort aimed at accelerating the development of grain sorghum breeding stocks which can be used by developing country cereal improvement programs.

The project will concentrate its work in three areas: (1) breeding, screening, evaluation, selection, and release of improved lines; (2) planting on a worldwide basis of nurseries such as disease and insect nurseries, lodging nurseries, grain weathering nurseries, mite resistant nurseries, and midge resistant tests; and (3) linkages and utilization activities.

weed resistance

The project to date has successfully joined ongoing sorghum improvement work, aimed at domestic problems, with efforts to convert superior types to forms adapted to the growing conditions of developing countries. To date, 120 converted strains have been developed in the Texas program and released for domestic and DC use. Much of the work involved in this conversion was begun before the project under AID-ta-c-1092 was undertaken; however, AID support enabled speedily completion of their development and has funded ongoing work which will lead to further releases.

Also, breeding stocks resistant to downy mildew, midge, and greenbug have been developed and released, and further improvements for these traits are in progress.

It is now contemplated that the program at Texas A&M, directed at needs of developing countries, will be expanded to an integrated sorghum improvement program aimed at the development of high yielding disease and insect resistant types. Other objectives will be to sp ed up release times, to enlarge cooperative efforts with DC national, regional, and international programs, to work more directly with DC sorghum specialists, and to increase training activities. All these efforts will be directed at faster utilization of improved sorghums in development programs in DCs where sorghum is a major cereal crop.

Texas A&M is considered to have the strongest public institutional sorghum improvement program in the world. About 20 staff members devote a major portion of their research and teaching time to sorghum improvement. This includes staff members with joint appointments to other institutions in the state, such as Texas Tech University at Lubbock. Broadbased graduate and professional training is available because of the joint academic and research activities of the staff.

Many sorghum cultivars developed in Texas are the basis for the rapidly expanding sorghum acreage in Argentina, Brazil, and Venezuela. The first hybrids in India used parent lines from the Texas Agricultural Experiment Station. Similarly the lines most productive in Israel, Korea, Lebanon, Vietnam, Yemen, and other areas are directly from the Texas sorghum program. In 1974, the Texas Agricultural Experiment Station undertook the AID project "Development of High Yielding Sorghum Cultivars with Disease and Insect Resistance". This program fostered a further expansion of sorghum research in Texas which has had application throughout the world.

The environments in Texas for growing sorghum are varied and parallel those of the majority of the arid, semiarid, and semi-tropical sorghum growing regions of the world. Many of the problems faced at Texas A&M are identical with problems faced by researchers in DCs.

B. Research Purpose and Expected Products

1. Purpose

To develop and make available to the developing countries and to regional and international centers high yielding varieties of sorghum with satisfactory nutritional value and multiple resistance to prevalent diseases and insects.

2. Objectives

a. To identify and catalog sources of disease and insect resistance, improved grain quality, and other desirable agronomic traits in partially converted and converted exotic sorghums and in other sorghums in the World Sorghum Collection.

b. To develop high yielding, agronomically desirable sorghums with with high levels of disease, insect and lodging resistance, as well as resistance to environmental stresses and desirable grain quality characteristics.

c. To develop agronomically elite populations of sorghum with high levels of disease resistance, insect resistance, lodging resistance, and improved grain quality characteristics.

d. To develop and establish efficient resistance screening techniques for detection and evaluation of host plant resistance.

e. To collect and evaluate populations of plant pathogens for their range or changes in virulence and to develop disease diagnostic systems.

f. To develop systems for managing arthropod pests of sorghum.

C. Significance and Rationale for the Research

1. The Development Problem

This research proposal fits well into A.I.D. goals and policies. Its aim is to increase sorghum production in the developing

countries through a program to produce varieties resistant to insect and disease problems. Research work will be conducted in Texas, at international centers, and in cooperation with national programs. Many of the diseases and insects which attack sorghum in Texas are the same as those found in the developing countries and research to date has shown that resistant varieties in Texas are generally found to be resistant when grown in DCs.

Sorghum is one of the principal food and feed commodities of the world. Sorghum is considered by many authorities as the third most important food grain, exceeded in utilization for food only by wheat and rice. Furthermore, sorghum is well adapted to cultivation under wide extremes in environmental conditions including arid, semiarid, and subtropical areas of the world where other food commodities are often less well adapted.

In southwestern USA, where sorghums are a principal agricultural commodity, serious disease and insect problems have occurred repeatedly. During the past few years, there have been grave losses caused by head smut (Sphacelotheca reiliana), downy mildew (Sclerospora sorghi); maize dwarf mosaic (MDMV); anthracnose (Collectotrichum graminicola; charcoal rot (Macrophomina phaseolina); Fusarium stalk rot (Fusarium moniliforme); and a number of common foliage diseases.

Insects causing significant yield losses in grain sorghum annually are the sorghum midge (Contarinia sorghicola), greenbug (Schizaphis graminum), and Banks grass mite (Oligonychus pratensis).

The development problem to be attacked by this project will be to broaden the program for disease and insect evaluation and testing so that converted lines are evaluated and selected for tolerance to physiological stresses, production efficiency and nutrition as well as diseases, pathogen strains, insects, mites, and environments of the developing world. The final goal is to develop dwarf or semidwarf sorghum lines, hybrids and bulk populations which are agronomically desirable, possess insect resistance and multiple disease resistance, are photoperiod-insensitive, environmentally tolerant, and can be utilized immediately in breeding programs in the DCs as sources of disease and insect resistance.

2. State of the Art which Supports this Research Proposal

The current contract is part of an overall AID effort to make improved sorghum varieties available to farmers in the DCs. The Texas A&M research component has been primarily concerned with the collection, breeding, and identification of sorghum cultivars with demonstrated resistance to the most common disease and insect attacks. This work complements other AID supported research to produce improved sorghum lines for DC use. Texas A&M has long been concerned with pest resistance in sorghum for temperate zones and has been able to meet needs of tropical and sub-tropical areas through AID support.

Field trials are conducted in Puerto Rico, Brazil, Mexico, and India. Professional linkages have been established with ICRISAT, ALAD, OAU/STRC (formerly JP-26), and country operations in Senegal and India. International breeding selections have been incorporated in the trials at Texas, and promising lines are included in the selections which are distributed for worldwide testing. Data recording sheets have been supplied by the contractor to ensure uniformity of result tabulation.

A continuous system is in operation for the preliminary screening, multiplication, advanced screening and distribution for field testing of promising cultivars as they are identified. Collaboration with sorghum specialists in other AID supported research at Purdue, Nebraska, and Puerto Rico has been frequent and close.

Conversion to temperate-adapted sorghums to tropical adaptation and vice versa has been an objective of the Texas sorghum improvement program for several years, and has been part of the AID funded work since 1974. Tropical adaptation enables sorghum types to be productive in short day, high temperature environments. One hundred and twenty converted lines developed in the cooperative Texas-ARS program have already been released, and more are under development. This program is vital to sorghum breeding work at the international centers and in DCs, since it makes available new disease and insect resistant germplasm sources, with height and maturity characteristics readily usable in both temperate and tropical areas.

The one hundred twenty converted lines released contain sources of midge, mite, downy mildew, head smut, anthracnose, and lodging resistance which are now being used in development of high yielding insect and disease resistant cultivars.

Sorghum releases approved during the past year by the Texas Agricultural Experiment Station include the following:

a) TAM Bk-43 Greenbug resistant B-line bulk

b) TAM BK-44 Greenbug resistant B-line bulk

c) TAM Bk-45 Downy mildew resistant yellow bulks

d) TAM Bk-46 Downy mildew resistant yellow bulks

e) TAM Bk-47 Downy mildew resistant yellow bulks

f) TAM Bk-48 Downy mildew resistant yellow bulks

g) TAM 2566 Midge resistant line

h) TAM 2567 Greenbug resistant yellow endosperm pollinator

i) TAM 2568 Greenbug resistant yellow endosperm pollinator

j) 120 converted lines from the sorghum conversion program.

The releases were products of the overall Texas Agricultural Experiment Station sorghum improvement program. They were developed and released by Texas Agricultural Experiment Station breeders, largely with financial support from sources other than AID, since the AID project did not begin until 1974. They are listed here because the final work was supported in part by AID, and because they typify the success and release policy of the Texas sorghum program.

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

Appropriate linkage relationships and coordination with national, regional, and international institutions are being developed. Texas A&M plans to enlarge these linkages each year of the proposed three year contract, as research results become available and breeding material is ready for release.

1. Linkages

This contract is part of an overall A.I.D. effort to make improved sorghum varieties available to farmers in the DCs. The Texas A&M research component is especially concerned with the collection, breeding, and identification of sorghum cultivars with demonstrated resistance to the most common disease and insect attacks. This work necessarily dovetails with other A.I.D. supported research for developing and distributing more reliable sorghum lines for DC use. Texas A&M has long been concerned with pest resistance in sorghum for temperate zones and is able to accommodate the interests of tropical and subtropical areas through A.I.D's support.

Field trials are being conducted in Puerto Rico, Brazil, Mexico, and India. Professional linkages have been established with ICRISAT, ALAD, OAU/STRC (formerly JP-26), and country operations in Senegal and India. International breeding selections have been incorporated in the trials at Texas, and promising lines are included in the planting material selections which are distributed for worldwide testing.

A continuous system is in operation for the preliminary screening, multiplication, advanced screening, and distribution for field testing of promising cultivars as they are identified. Collaboration with sorghum specialists in other A.I.D supported research at Purdue, Nebraska, and Puerto Rico is frequent and close.

2. Expected End Result

The broad spectrum of investigations should permit the cataloguing of thousands of cultivars into categories of salient attributes. On-going breeding programs will combine desirable traits. The end result will be a reserve of plant materials with proven characteristics which will be available for individual country or regional multiplication or cross breeding into indigenous lines. In essence, the combined efforts of the A.I.D. thrust would eliminate the need for duplication of these exacting and time consuming efforts by each DC seeking an improvement in sorghum production. Nonetheless, each beneficiary country will need to conduct the final phase of field trials in its own environments. Such testing is already under way in several countries which are cooperating in the evaluations.

Expected results should lead to increased food productivity in DCs., more reliable harvests, and less dependence upon chemical pesticides.

3. Utilization Plans

The present channels for dissemination of the findings of this project seem rational and adequate. They utilize the established information centers, particularly ICRISAT, ALAD, OAU/STRC in Nigeria, a regional center in Senegal, and the Indian Agricultural Research Institute. Additional national programs will be added for dissemination of the breeding material.

The rapidity with which findings are utilized in any individual country program depends upon the interest and professional capability in that country. To upgrade this national sorghum breeding capability Texas A&M will involve DC graduate students and professionals in the on-campus contractor activities. This will be accomplished by involving foreign advanced degree candidates in the operations and by holding special short courses or workshops and through in-country training.

E. Management Considerations

No unusual management problems are expected to arise in connection with this project renewal. It is similar in concept and design to other centrally funded crop improvement research projects.

Project will be evaluated through a review and evaluation team visit to the campus, through survey of field activities, and by constant review of the project monitor in TA/AGR.

It is anticipated that the contract will be a sole source procurement based on the contractor's excellent performance under the original three-year contract and the Texas A&M competence and experience in developing disease and insect resistant sorghums.

Contractor will clear manuscripts with TA/AGR before the publication of any articles resulting from this research.

F. Project Background Description

In 1963, the Texas Agricultural Experiment Station and the United States Department of Agriculture initiated a program in which exotic sorghums from the World Sorghum Collection are converted from tall, late maturing, photoperiod-sensitive types to shorter, earlier maturing, less photoperiod-sensitive lines. During the following conversion, they have been able

to evaluate resistance in many partially converted and converted exotic sorghums to diseases prevalent in the United States. This screening has shown that the conversion materials are outstanding as sources of resistance to essentially all economically important diseases and insects of sorghum. Of special significance was the finding of a large number of agronomically desirable lines with high levels of resistance to downy mildew and anthracnose, two diseases for which agronomically desirable resistant sources were not available prior to screening conversion materials. Also sources of resistance have been found to head smut, maize dwarf mosaic, rust, zonate leaf spot, gray leaf spot, bacterial stripe, leaf blight, and fusarium head blight. Outstanding sources of resistance to the various types of lodging as well as resistance to charcoal rot have been identified. Similar progress has been made in detecting sources of resistance to insects and mites and to sorghum midge, spider mites, and corn leaf aphids.

High lysine grain was found in 1973 in a line with the conversion program; this grain has approximately twice the amount of lysine of normal grain. However, the kernels are shrunken with a floury endosperm and have poor weathering properties. Superior weathering resistant lines have been crossed to high lysine lines to improve their weathering resistance.

Forty partially converted bulks and 183 fully converted lines have been released to private and public breeders. However, there are many sorghums yet to be converted and host plant resistance evaluation for many of these converted lines is far from complete.

Many of the desirable characteristics found in conversion materials mentioned above have been or are in the process of being transferred to other agronomically elite breeding lines, and have been successfully incorporated into the Texas Agricultural Experiment Station breeding and improvement program. The overall performance of such material from this program is very encouraging.

The sorghum conversion program will continue to provide the majority of new germplasm for source materials for disease resistance, insect resistance, lodging resistance, improved grain quality characteristics, desirable physiological responses such as sources of stress tolerance, and improved yield potential in both temperate and tropical areas.

In entomology the project is attempting to develop pest management strategies for pests of grain sorghum and to integrate all available means of manipulation of insect numbers into a system which creates minimum ecological upset to the agroecosystem. Specific areas of research include: economic injury levels, selective insecticides, natural insect control, and insect resistant sorghums.

In breeding the project has been evaluating conversion materials for disease resistance, lodging resistance, and breeding potential. Breeding of sorghums - using primarily new germplasm sources, with high yield, disease resistance, lodging resistance, grain weathering resistance, improved quality and improved drought stress tolerance - has been the emphasis of the project activities to date.

Texas A&M employs on this project four coprincipal investigators, one plant pathologist, two plant breeders, and one entomologist. In addition there are 13 coworkers in the fields of pathology, entomology, physiology, plant breeding, agronomy, chemistry, genetics, virology, and agricultural engineering.

G. Project Design and Method

1. Objective 1 - To identify and catalog sources of disease and insect resistance.

Primary disease and insect evaluation will continue essentially as under the current program. Selected sorghum introductions, as they become available, and appropriate converted and partially converted exotic lines will be screened for downy mildew, head smut, foliage diseases, sorghum webworm, corn earworm, corn leaf aphid, yellow sugar cane aphid, sorghum midge, and spider mites in nurseries at the appropriate locations. Breeding lines will be screened and evaluated for resistance to downy mildew, head smut, maize dwarf mosaic, lodging, charcoal rot, greenbug, midge, and spider mite. They will also be evaluated for anthracnose, seed mold, head blight, gray leaf spot, zonate leaf spot, leaf blight, rust, and bacterial stripe when sufficient levels of infection are present. Lines and selections with high levels of disease and insect resistance will be advanced to the "All Disease and Insect Nursery" (ADIN) in which they will be grown for disease and insect resistance evaluation under a greater variety of conditions. Those lines with the highest levels of disease and insect resistance, along with appropriate controls, will be made available for the International Disease and Insect Nursery (IDIN). The IDIN program permits advanced screening of superior sources of resistance to disease and insects in hostile environments throughout the sorghum growing world. During the past 3 years nurseries have been evaluated in 30 locations. This program will be continued in cooperation with ICRISAT, IRAT, and the All India Sorghum Program. The IDIN will be distributed to all persons requesting nursery seed and to others interested in obtaining promising sorghum germplasm.

2. Objective 2 - To develop high yielding, agronomically desirable sorghum varieties and lines.

Source materials identified with high levels of disease, insect, and lodging resistance, as well as those with desirable grain quality characteristics and tolerance to environmental stresses, will be utilized in breeding programs to incorporate said characteristics into high yielding, agronomically elite lines, and hybrids. Source materials will be crossed with each other and to elite U. S. lines to combine desirable characteristics. Intensive screening of early generation breeding materials will be used for the various diseases, insects, and other characteristics to select for even higher or improved levels of each trait. Standard breeding techniques such as crossing, backcrossing, and pedigree line selection will be primarily used.

Superior materials from the breeding program will be selected for entry in various uniform nurseries such as the ADIN and IDIN. A few superior yielding, agronomically desirable sorghums which possess some outstanding characteristics, will be advanced to a uniform yield trial. This trial will likely contain both lines and hybrids as well as open entries for locally used sorghums. Such a trial will be grown at a few key locations throughout the world. These trials will provide useful data on general adaptation and yield under a wide range of environments, as well as on stability of disease and insect resistance. Close liaison with ICRISAT and other international centers in such international trials will be developed.

3. Objective 3 - To develop elite breeding populations of sorghum with high levels of resistance to disease and insects.

Disease and insect resistant populations have been established using materials developed through the overall sorghum improvement program. Most of these populations have superior agronomically adapted types included and have been mated three or more times. Those items selected which have the appropriate disease and/or insect resistance will be evaluated for combining ability and if they show merit will be included in new restorer and nonrestorer populations of high source materials. All populations will be open ended allowing the continued addition of superior material when it is isolated. Random mating will be done in the winter in Puerto Rico and during the summer at Lubbock. Populations will be evaluated following natural and artificial inoculation with pathogens. In some populations only resistant plants will be allowed to random mate. In other populations, S_1 lines will be evaluated for disease and insect resistance prior to recombination. A population improvement scheme based on S_1 and half-sib testing to reduce hazards of specific

gene resistance has been initiated and will be advanced. These random mating populations will serve as source populations for sorghum improvement including evaluation for yield, physiological stress resistance, seed quality, and nutrient utilization efficiency studies. These improved populations will be distributed worldwide.

4. Objective 4 - To develop efficient resistance screening techniques.

Virtually all techniques used in evaluation of host resistance can be made more efficient. The recent improvement in downy mildew inoculation (Craig, 1975) permits off season testing for reaction to downy mildew in the greenhouse, thereby reducing the time required to transfer downy mildew resistance and the numbers of entries needed in field nurseries. Similarly, more efficient techniques are needed for head smut, anthracnose, seed mold, charcoal rot, midge, and mite evaluation. Technique improvement is essentially a naturally evolving component in host plant resistance work. In critical areas, such as resistance to downy mildew, head smut, stalk rots, insects, and mites, studies on the nature of resistance will be required. The type of resistance will determine, in part, the vulnerability of the host and will permit incorporation of more than a single source or different combinations of resistance in improved lines. In addition, complementary studies are needed at times to evaluate selected cultural, biological and chemical control for certain diseases and insects. Such studies as inoculum removal, (including destruction of alternate hosts) management of hyperparasites and cultivation practices, can be used to augment host resistance genes and resistance diseases epidemics or insect populations. A key point in this program is that other appropriate disease and insect controls will not be ignored by relying solely on host plant resistance.

5. Objective 5 - To evaluate populations or plant pathogens for their range or changes in virulence.

Collections and isolates of key pathogens will be brought to College Station and evaluated under controlled conditions. However, race identifications will not be the prime consideration of this program, rather it will be used to augment the ADIN, IDIN and Uniform Disease Nurseries, as a tool for evaluation of host resistance (Frederiksen, et al., 1974, 1975). The genetic variability and range in virulence of plant pathogens is necessary. A component of this program will be the initiation of critical disease diagnostic services such as identification of specific races of pathogens and laboratory identification of virus or viruslike organisms through use of antigen properties.

6. Objective 6 - To develop systems for managing arthropod pests of sorghum.

Identification of germplasm possessing differing levels of resistance to the greenbug, corn leaf aphid, sorghum midge, and spider mites has resulted from the current program. Resistance mechanisms involved have been identified or are currently being studied. Pest resistant sorghums will be integrated with natural biological control. A Texas program of biological control of arthropod pests of grain sorghum was initiated in 1972.

The objectives of the current biological control program are to obtain efficacy data on the more abundant, indigenous natural enemies and to introduce and establish new, exotic natural enemies. Research currently in progress includes the following: a) evaluation of native natural enemies of greenbug, sorghum midge, and spider mites in central and west Texas; b) release and evaluation of an exotic parasite of greenbug; and c) release and evaluation of 4 exotic, phytoseiid predators of spider mites. Cooperation with the USDA-ARS Beneficial Introduction Laboratory, currently engaged in seeking new exotic parasites of greenbug in France and Mediterranean countries, is expected to provide additional parasite and predator species for future releases. Cooperation with personnel affiliated with the University of California at Riverside will provide additional exotic species of photoseiid predators of spider mites. Each species of natural enemy released represents new opportunities for a successful program in sorghum production. Beneficial arthropods identified and studied as part of the Texas program are also obvious candidates for release in other sorghum producing countries with the same or closely related pest species.

H. Work Plan - First Year

1. Breeding, Screening, Evaluating, and Selecting

These activities involve an integrated interdisciplinary approach toward the development of tropical sorghums for cultivation in temperate and tropical regions. The work plan stresses ecologically sound host plant resistance as a means of combating diseases and pests.

a. Evaluate and screen selected sorghum introductionsaas they become available and appropriate converted and partially converted exotic lines for downy mildew, head smut, foliage diseases, webworm bollworm, corn leaf aphid, yellow sugar cane aphid, midge, and mite.

b. Screen and evaluate breeding lines containing disease and insect resistance to downy mildew, head smut, maize dwarf mosaic, lodging, charcoal rot, greenbug, midge, and Bank's grass mite. Continue testing to find the ideal chemicals for controlling downy mildew.

c. Artificial inoculations with selected pathogens will be done to complement natural screening programs during off seasons when natural infection is not possible and for studies on nature and mechanisms of host resistance.

d. Biological, chemical, and cultural control of selected pathogens will be studied as a means of enhancing host resistance or as alternate means of control.

e. Several populations containing disease and insect resistance will be grown and random mated. These populations include TP13, TP14, those with MDM resistance, lodging resistance, and head smut resistance. Up to 100 lines from existing populations will be screened for heat smut resistance at a minimum of eight Uniform Head Smut Nurseries.

f. Selection from TP8R (midge resistant population) will be evaluated to identify those lines to be composited for additional random matings. Selections will be made of improved agronomic types for inclusion in the midge breeding nursery.

g. Continue to backcross previously identified greenbug resistant lines to elite U. S. lines to transfer the genes for resistance into improved agronomic types.

h. Continue screening and evaluation of sorghum midge resistant sorghums; continue screening trials of regional tests of selected material. Develop a uniform testing program of screening midge resistant sorghums by manipulating planting dates and adult midge counts.

i. Continue to improve techniques for determining the mechanisms of resistance to the sorghum midge and spider mites. Compare resistant and susceptible sorghums under natural and introduced infestations.

j. Make extensive tests to examine both the tropical adaptation and combining ability of several females to standard males to determine yield potential of the tropical adaptation characteristic. (Tropically adapted females by a standard male have produced significantly greater yield than any commercial hybrid tested.)

2. Nursery Trials

a. The International Disease and Insect Nursery (IDIN) will include new and improved disease and insect resistant sources. The IDIN will be distributed to all those requesting seed throughout the world - 22 locations last year with a goal of 30 locations in 1977. The IDIN has been a 30 entry test composed of the best multidisease and insect resistant sorghums along with appropriate elite sorghum control varieties and disease differentials. Countries which will receive the IDIN include Argentina, India, Mexico, Senegal, and Venezuela.

b. The All Disease Nursery (ADN) will include improved disease resistant sources as well as elite insect resistant sources. The ADN will be tested against the widest range of diseases possible under a wide range of environmental conditions. Twenty-three, 70 entry, two replication tests were planted this year - 32 entries were highly resistant to downy mildew. A greater number of nurseries with a larger number of entries are planned for 1977.

c. Lodging nurseries will be planted at several locations to screen promising lines for the several types of lodging which may occur, such as root lodging, weak neck, moisture stress charcoal rot type lodging, after freeze stalk breakage and insect lodging complexes. The best sources of lodging resistance have been placed in the Statewide Lodging Test (SLT). Fifteen of these tests were planted this year and the number will be increased in 1977. Other lodging tests to be planted will be the 36 entry Advanced Lodging Test (ALT) and Preliminary Lodging Tests (PLT) and the 97 entry Hybrid Lodging Test (HLT).

d. The Grain Weathering Test (seed mold) will be grown at several locations under severe weathering conditions to screen for resistance to seed mold. A 25 entry replicated test containing lines with the least weathering was planted at nine locations this year. A program of like magnitude will be continued in 1977.

e. A replicated Midge Resistant Test will be assembled from the midge resistant lines and grown at several locations in 1977. Several sorghum breeding lines have been identified as resistant to the sorghum midge. None of them possess the yield potential necessary for producer acceptance. An intensified breeding program to transfer resistance to disease resistant types with high yield potential will be undertaken.

f. Nurseries will be established to evaluate mite resistant sorghums - hybrids and derived breeding lines.

2. Linkage and Utilization Activities

a. Selected elite disease and insect resistant breeding lines will be released and distributed as they are identified and seed is increased. Proposed candidates for release are:

Tx 2714 - Tx 2733	-	disease resistant zerazera derivative restorer lines
Tx 2734 - Tx 2748	-	greenbug resistant restorer lines
Tx 2749 - Tx 2752	-	greenbug resistant A and B lines
Tx 2567 - Tx 2573	-	lodging and charcoal rot resistant, mite resistant, disease resistant restorer lines
Tx 2753 - Tx 2757	-	grain weathering resistant, Cercospora resistant, lodging resistant, high yield, disease resistant restorer lines
TAM Bk's	-	six downy mildew resistant sudan type bulks
TAM Bk's	-	eight downy mildew resistant forage type bulks
TP2R	-	multiple disease resistant population
TP6B	-	standard B-line population
TP7B	-	disease resistant B-line population.

b. Evaluate the performance of greenbug resistant sorghums under expanded acreage as grown by producers.

c. Meet at least once each year with other A.I.D. financed institutions involved in sorghum improvement to review results and exchange information.

d. Conduct field trials in a minimum of 8 DCs.

e. Maintain and expand linkages with ICRISAT, ALAD, OAU/STRC, and country operations in Senegal, India, and a minimum of two other developing countries.

f. Develop training programs for professionals and graduate students from developing countries, develop and implement short courses and workshops, and conduct in-country, on-the-job training for DC sorghum researchers.

I. General Appraisal

This project renewal has been given high priority by the TA/AGR Crop Production Division. The proposal is sound in design and cost estimates (although larger than those of the first three year contract)

are appropriate to the level of effort intended. The increased emphasis on getting research results into the sorghum breeding programs of the developing nation and international agencies accounts for the intensified activities and increased budget estimates.

A detailed review of the on-going project should be conducted before the end of the first three year period of operations - to assess progress, to evaluate the size and direction of the proposed research efforts, to consider the needs of the DC institutions and to determine any possible need for redirection.

The contractor has a strong staff with outstanding experience and competence in developing disease and insect resistant sorghum varieties. One variety developed for resistance to the greenbug has been released and commercial hybrid companies have enough seed available for 5 million acres in 1976.

Progress to date on the first three year phase of this contract has been exceptional and performance of the staff has been excellent.

J. Environmental Considerations

Typical of crop improvement research projects financed by A.I.D. there are no environmental problems expected from the proposed renewal of this research project nor from adoption of the improved materials. Since the project is aimed at developing disease and insect resistant sorghums for developing countries, it follows that as these improved varieties are utilized by growers that the requirements for pesticides and chemical control methods will be reduced.

K. BUDGET INFORMATION

March 1, 1977 - February 29, 1980 - Three Year Budget

	1st yr.	2nd yr.	3rd yr.
Wages and Salaries	116,500	126,500	150,000
Fringe benefits	10,458	11,310	13,688
Overhead	57,145	61,985	73,500
Equipment and Supplies	31,766	30,000	30,000
Travel and per diem	45,039	50,000	50,000
Other Direct Costs	29,092	30,205	32,812
	290,000	310,000	350,000

Three year total - 950,000

Proposed 1977-1978 Budget by Project Activities

	Per Cent Of Total
Breeding - Sorghum Entomology	24%
Breeding - Sorghum Pathology, Lodging	21%
Pathology	22%
Entomology	19%
International Testing Program	14%

L. New Positions

The budget includes salary for the following three new positions:

-- Entomologist at College Station to assist in establishing, rating, and harvesting insect nurseries during the summer, and establishing and maintaining greenhouse insect cultures and conducting screening trials during the winter.

-- A research associate to assist in threshing and preparing seed to be grown in all of the disease and insect nurseries, at Lubbock. He also will assist in planting and caring for nurseries, in inoculation, making disease and insect ratings and harvesting, as well as preliminary summarization of data.

-- At College Station, a plant scientist to conduct International Disease, Insect and Performance Nurseries. He will partially summarize these data, work with data processing, and jointly establish seed increase programs.

AID 1020-29 (1-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 3/1/77 to 2/29/80
Total U. S. Funding $950,000
Date Prepared: 5/20/76

Project Title & Number: Improvement of Grain Sorghum for Developing Countries (DCs)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To increase quantity and nutritional value of food crops in developing countries.	Measures of Goal Achievement: 1. Significant increase in per capita production of major food crops in DCs. 2. Improvement in nutritional quality of major DC food crops.	1. Official production and population statistics (FAO, Foreign Agricultural Service estimates). 2. Nutritional quality surveys in DCs.	Assumptions for achieving goal targets: 1. DCs will actively attempt to expand food crop production. 2. Nutritional quality can be improved without major constraints on yield.
Project Purpose: To make available to DCs high-yielding, nutritious varieties of sorghum with multiple resistance to moisture and temperature stresses, diseases and insects, together with improved practices for their cultivation.	Conditions that will indicate purpose has been achieved: End of project status. 1. New, superior varieties available to farmers in DCs. 2. Research and development activities in sorghum effectively assumed by DC agencies and international institutions and linked by communications network.	1. Publication and reports of DC governmental agencies; on-site inspections of seed supply. 2. On-site inspection and review by AID/W personnel and consultants.	Assumptions for achieving purpose: 1. Solutions can be found to major constraints. 2. Agriculture extension services are able and willing to promote proven practices. 3. DC research institutions develop adequate capabilities.
Outputs: 1. Identification of superior germ plasm. 2. Incorporation of desirable traits into broadly-adapted varieties suitable for DC use. 3. Evaluation of improved varieties and practices in DCs. 4. Training of DC personnel in sorghum research. 5. Establishment of effective linkages with DC agencies.	Magnitude of Outputs: 1. Not quantifiable. 2. At least 2 superior varieties for each major agroclimatic region. 3. At least 1 test location in each major sorghum-growing zone. 4. Total of 10 DC trainees completing training. 5. Linkages with 3 international centers and at least 10 DC institutions.	1. Reports by contractor. 2. Reports by contractor, USAIDs, DC cooperators, and international agencies. 3. Same. 4. Contractor reports. 5. Contractor reports, communications and reports from DCs and international agencies.	Assumptions for achieving outputs: 1. DCs and USAIDs will request technical assistance; research findings will be available. 2. Cooperation of DCs. 3. Interest and resources exist in DCs. 4. Collaboration of international institutions. 5. Sufficient interest among DCs and qualified personnel.
Inputs: 1. AID/W provides financial support and project guidance. 2. Contractor provides qualified personnel and backstopping facilities. 3. Participating personnel and cooperation provided by 1) DCs, 2) USAIDs, and 3) international organizations.	Implementation Target (Type and Quantity) 1. AID/W funding at approximately $950,000 for 3 yrs. 2. 70 man months/year technical personnel; adequate laboratory facilities; 5 or more acres field research area. 3. Not directly quantifiable.	1. AID/W records. 2. Contractor reports, on-site inspections. 3. USAID reports, on-site verification.	Assumptions for providing inputs: 1. AID/W funding will be available on schedule and in quantity agreed upon. 2. Contractor will have necessary qualified personnel; university facilities will be available to project. 3. International organizations, USAIDs, and DCs will have personnel and resources to support this activity.