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REPORT OF

EAST-AFRICAN FOOD CROPS RESEARCH PROJECT

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EAST-AFRICAN FOOD CROPS RESEARCH PROJECT

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EAST AFRICAN FOOD CROPS RESEARCH REPORT

M A I N R E P O R T

I. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. General Description of Project

Proposed is a Research Project designed to provide fundamental assistance to Partner States in the East African Community[1] which will enable them to accelerate the production and nutritional value of selected food crops. Also proposed is a continuation of support for a plant quarantine station which currently inspects, propagates and distributes introduced plant materials to the three East African countries. The four specific areas are as follows:

1. MAIZE - SUBPROJECT A

a. Protein Quality Laboratory - Subproject A-1

Incorporation of high quality protein with vitreous endosperm into high yielding maize populations or hybrids requires a means of determining chemical content of maize seeds without destroying them. The proposed protein laboratory would satisfy this need. This laboratory while concentrating on screening maize germ plasm will also service other cereal breeders in East Africa - proposed site for this laboratory is at Kitale, Kenya.

b. Breeding for Disease Resistance - Subproject A-2

It is proposed to develop an overall disease resistance program to solve serious problems which now reduce yields of maize in low elevation areas of East Africa. The initial focal point will be for resistance to virus diseases, such as Maize Streak and Sugarcane Mosaic Viruses. Identification of the viruses and of sources of resistance to streak makes this program feasible at this time. The breeding center is proposed for Kibaha, Tanzania.

c. Continuation of Breeding Methodology Research - Subproject A-3

The maize breeding methodology program currently underway at Kitale, Kenya, consists of the investigation of breeding methodology coupled closely with the development of improved maize varieties for high altitute areas. This methodology research, while very successful to date, requires an additional two-year period for completion. Results of this effort in the future will be tied closely to a new effort to incorporate a high quality protein endosperm in the high yielding populations developed thus far.

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[1] Project assistance would be channeled through the East African Agriculture and Forestry Research Organization, (EAAFRO) which is the official agricultural research unit for the community.

2. AGRONOMETEROLOGY (CROPPING SYSTEMS FOR MARGINAL RAINFALL AREAS) SUBPROJECT B

A description of the research project recommended as summarized in Table 3 of the subproject report follows:

Basic research on growth characteristics of major food crops to quantify their influence on crop water requirements and on the actual water regime, and to quantify yield responses to water deficits in different growth periods.

Development of the capability to combine data on crop yield responses to water deficits with climatic and soil water measurements to predict the actual water regimes and the consequent crop yield expectations.

Serve as a center for data collection, computation and interpretation. This includes all available meteorological and soils data, plus the research findings at all levels of this and related studies.

Serve in the role of coordinator of, and liason between, all research activities related to food crop production in the marginal rainfall areas by all agencies whether EAAFRO, international agencies, national governments or universities.

Serves as an active disseminator of recommendations for field application of research findings by actively conveying useful information to national planners, research leaders in Partner States and personnel of agencies dealing with development in marginal rainfall areas such as UNDP-FAO, ICRISAT, IITA, World Bank, etc.

Serve as a computational and output center for annual cropping system recommendations based on soil water monitoring at key sites in marginal rainfall areas and on long range weather forecasting.

3. SUGARCANE RESEARCH - SUBPROJECT C

This subproject proposes to support on-going sugarcane research at Kibaha, Tanzania, in an attempt to assist the Partner States to increase sugar production to the point of self sufficiency. Much progress toward achieving this goal can be made, if in addition to the new sugarcane acreages contemplated, some of the numerous problems now plaguing growers can be solved. Most serious of these problems are insect pests, diseases, poor yields due to inferior varieties, and a multiplicity of suboptimal cultural practices.

4. PLANT QUARANTINE - SUBPROJECT D

The East African Plant Quarantine Station located at EAAFRO headquarters is a vital link in the protection of East Africa from the introduction of diseases and pests of all descriptions. For the past five years, USAID has been assisting EAAFRO by furnishing an experienced Plant Quarantine Officer (Plant Pathologist) to direct the operation of the Plant Quarantine Station. By June, 1978, EAAFRO should be in a position to appoint a trained East African Plant Pathologist as Director of the Station.

Following the completion of the incumbent's tour, USAID has been requested to furnish a qualified Plant Pathologist to continue the work for a two year period while a qualified East African Plant Pathologist is being trained to take over this position.

B. Summary of Findings

EAAFRO - GENERAL

- Has important leadership role to play in food crops research. Only a minimum effort is being expended in this area at present.
- Found to be a fully operational organization with the capacity to efficiently conduct important research on food crops.
- Needs to narrow the scope of activities and concentrate on highest priority needs. Food crops research offers a unique opportunity.
- Greatest strengths are capable personnel with good leadership and generally adequate facilities and budget.
- Greatest potential weakness is inability to recruit and keep superior scientists due to inferior salary structure relative to other research establishments in East Africa.
- Excessive time required to change programs because cumbersome EAC policies constrain response to pressing problems.

1. SUBPROJECT A-1 - PROTEIN LABORATORY

Kitale, Kenya, found to be most desirable site because of available physical facilities and proximity to major potential users. Forty percent of the initial work will originate in the vicinity of Kitale. Site is acceptable to all Partner States.

Relative simplicity of instruments and methods make essential operation by East African technicians feasible.

Requirement of timeliness of data precludes dependence on distant laboratories.

a. Utilization of Facility

All Partner States recognize the breeders need for this facility to permit proper selection procedures for improved protein quality in cereals and subsequently in legumes.

Volume of samples to be tested justify the facility - estimated number for first year in near capacity of 10,000 samples.

Location of East Africa will give East African breeders rapid and priviledged knowledge of sources of high quality protein maize populations.

b. Logistics for Continued Operation Following Termination of USAID Support

EAAFRO and GOK will continue to supply and maintain required land and buildings.

Following training in the U. S. and CIMMYT, and on-the-job training, one of two East African Laboratory Technicians will assume full responsibility for management of the laboratory.

After the initial opening of the laboratory EAAFRO will financially underwrite its operation - thus AID termination of support won't impose an additional financial burden. Costs of laboratory expansion beyond the needs of Partner States would be defrayed by the new users.

c. Need for Protein Analysis

High quality protein composition cannot be visually discerned especially in vitreous endosperm. Breeders need the laboratory to make possible effective selection.

Given the dominance of maize in diet of rural East Africans (about 90% of population), varieties of maize with improved quality protein can greatly influence overall level of nutrition.

d. Cost of Subproject

USAID	$212,350
EAAFRO	163,930
TOTAL	$376,280

2. SUBPROJECT A-2 - BREEDING FOR DISEASE RESISTANCE IN MAIZE

a. Overall Feasibility of Initiating Programs

- Potential for increasing maize production in low altitude areas reduced by incidence of virus diseases. Large acreages are available for maize plantings if disease can be controlled.

- Preference is for maize, but Cassava is planted and eaten because of poor maize yields.

- Sources of resistance to the major virus disease is available - resistance screening techniques have been worked out.

- Parental material with good agronomic characteristics is also available.

- Breeding offers best potential for solution - roguing out diseased plants has not proven effective.

b. Need for Maize Breeder and Plant Pathologist

- Anticipated difficulty in locating satisfactory breeder/pathologist.

- Present British ODA Pathologists at Muguga are over committed on other assignments. EAAFRO has no pathologist available for work in Partner States at present.

- Breeder needs to concentrate on populations for low altitude where in contrast to high altitude areas there is less adapted material.

- Plant Pathologist could support the Plant Quarantine Station (especially sub-stations if they materialize) and the sugar cane breeding work.

c. Feasibility of Locating Field Work at Kibaha, Tanzania

- Environment conducive to high incidence of disease, thus facilitating selection for resistance.

- Is in close proximity to EAAFRO sugarcane station with associated advantages of housing, office and laboratory space, use of equipment and consultation with other scientists.

- Other sites lack housing, irrigation, etc.

- Land is available close to the sugarcane station.

- Some conflict with best interests of sugarcane station because of danger of introducing more disease in cane plantings.

- Having a corn breeder at Kibaha should make the proposed sugar-cane positions more attractive because of possibility of idea exchange, etc.

d. Cost of Subproject

USAID	$517,100
EAAFRO	104,040
TOTAL	$621,140

3. SUBPROJECT A-3 - CONTINUATION AND TRANSITION OF MAIZE BREEDING METHODOLOGY RESEARCH

a. Feasibility of Incorporating Opaque-2 into Breeding Methodology Study

- Parental materials are available to make incorporation genetically feasible - assuming that protein laboratory is available to facilitate selection.

- Over ten year period the maize genetics group at Kitale have been exceptionally successful in accomplishing stated objectives.

- Technician can phase this program in while completing long term methodology study. He can utilize methods proven in the study.

- The need for developing high quality protein maize has been established as a major portion of East Africa's people rely heavily on maize for food.

- Project can be conducted with present land and facilities at Kitale, Kenya.

b. Possible Conflicts Between the Program for Incorporating Opaque-2 and Completion of the On Going Methodology Study

- Completion of the evaluation study will not require full effort of the USDA/AID maize geneticist - this can add an important new dimension to his work.

- AID technician must understand and follow priorities suggested if the methodology study is to be completed as scheduled. The priorities are:

  i Evaluation of completed experiments on selection.

  ii Make provision with counterpart personnel for completion of methodology study - 3/17 of which will not be available for analysis within the two years.

  iii Introduce opaque-2 into EAAFRO breeding populations.

c. Status and Utilization of Methodology Study

- Have successfully demonstrated possibilities of using population improvement rather than traditional inbreeding and line evaluation methods.

- Seven African countries have formed composite breeding population based on methods study results.

- Extension of results is formalized in workshop setting (EAAFRO and other States)

- EC 572 (R12)C2 is the male parent for 76 percent of hybrid seed sold in Kenya.

d. Cost of Subproject

USAID	$144,400
EAAFRO	296,860
TOTAL	$441,260

4. CROPPING SYSTEMS FOR MARGINAL RAINFALL AREAS - SUBPROJECT B

a. Overall Feasibility of EAAFRO Leadership in Research on Marginal Rainfall Areas

- EAAFRO has a long and distinguished tradition in the research areas related to this subproject including research in sorghum, millets, and maize and in the areas of soils and agronometeorology.

- Facilities are well laid out and maintained.

- It is anticipated that they will have serious difficulty in recruiting qualified personnel if salaries are not brought up to competitive levels.

- It is felt that the proposed subproject is within the capabilities of EAAFRO and that it should serve to maintain EAAFRO's reputation as a premier research institution in the area of agrometeorology.

b. Suggested Role for EAAFRO in an Integrated Marginal Rainfall Study Program

- Basic research on growth characteristics of major food grains and legumes to quantify their influences on crop water requirements and on the actual water regime, and to quantify yield responses to water deficits in different growth periods.

- Development of the capability to combine researched crop characteristic findings with planting site (marginal rainfall areas) measurements of climate and soil to predict the actual water regimes and consequent crop yield expectations.

- Development of the capability to predict the time (growth stage related) pattern of water deficits and their impacts on yield for any combination of crop, climate and soil, and to utilize this estimate to further predict the optimal application pattern for any supplementary irrigation water supply which may be available.

- Serve as the center for data collection, computation and interpretation. This includes all available meteorological and soils data, plus the research findings at all levels in this and related studies.

- Serve in the role of coordinator of and liason between all research activities related to food crop production in the marginal rainfalls areas by agencies, whether EAC, international, national governments, universities, or other.

- Serve as an active disseminator of meteorological, soil, and crop information, and of recommendations for field application of research findings which have reached the stage of usefulness. The suggestion here does not include village level extension, but rather the active conveying of useful information to national planners, national experiment station staff, personnel of the agricultural extension services and soil conservation services, and to personnel of research related agencies such as UNDP-FAO, ICRISAT, IITA, World Bank, etc.

- Eventually to serve as computational and output center for annual cropping system recommendations based on soil water monitoring at key sites in the marginal rainfall areas and long range weather forecasting. Still later this capability may be transferred to marginal area centers as a continuing service to agriculturists affected.

c. Cost of Subproject

USAID	$1,061,000
EAAFRO	284,660
TOTAL	$1,345,660

5. SUGARCANE RESEARCH - SUBPROJECT C

a. Overall Feasibility

- The subproject will facilitate current work at the Kibaha Station and will produce two new sugarcane varieties in the next two to three years.

- Methods for inducing and synchronizing flowering of cane have been developed and are being used.

- There is a nucleus of trained EAAFRO and national center professional and support staff who can carry out the program if some assistance is provided.

- Kenya and Tanzania are both expanding sugarcane acreages and processing facilities. Excellent support of sugarcane research can be expected.

- The Director of EAAFRO gives this subproject high priority among the six proposed subprojects.

b. Ability to Use Sugarcane Research Information Generated by EAAFRO

- Both public and private sugarcane estates are clamoring for assistance. Evidence of utilization is the widespread trial of new varieties as they are introduced.

- Estates have some trained field personnel who can help in obtaining data and in getting field application of research findings.

c. Feasibility of the Kibaha, Tanzania Site to Carry Out the Proposed Research

- Sugarcane research is feasible at the Kibaha Station.

- The station is operational to a substantial degree. Good work on variety testing and breeding new clones is underway. The station is well managed.

- The station is in an environment conducive to sugarcane flowering. This is important in a breeding program.

- Land and facilities are generally adequate. Better irrigation facilities are needed as is equipment for new soils laboratory.

- Housing is available for two USAID technicians. Distance to schools may be a problem.

d. Economic Advantage of Foreign Exchange Substitution of Sugarcane

- The possibility of reducing heavy demands in foreign exchange by increasing domestic sugar production is realistic under current conditions of price and land availability.

- The extent of gain to be realized by expanding sugar production is limited to the increment of yield that can be obtained form existing acreage plus additional production which can be obtained by employing land and labor not currently being utilized for other crops.

- Based on limited evidence, it appears that the sugar industry could enjoy a comparative advantage relative to some other major producing areas in the world. This assumes adequate research support in the areas of crop improvement, disease resistance, soil and water management, and provision of adequate economic incentives to sugar estate managers.

e. Cost of Subproject

USAID	$ 600,400
EAAFRO	691,990
TOTAL	$1,292,390

6. PLANT QUARANTINE STATION - SUBPROJECT D

a. Overall Feasibility

- The Plant Quarantine Station is fully operational. The glasshouse space was doubled in 1973. A trained EAAFRO staff, except for a Plant Pathologist, is on board and its primary function has been carried out with increased effectiveness since 1954.

- The main EAAFRO station at Muguga of which the Plant Quarantine Division is a part, is a thriving and progressive research institution under capable leadership.

- The climatic conditions are satisfactory for all but a few tropical crops, such as sugarcane (a suggestion for managing this crop appears in Section IV-A of the subproject report).

- The Station is performing a vital function and is supported by Partner States.

- Any weakening of the Station could lead to establishment of separate quarantine stations in the Partner States. This would be a disaster in terms of less effective control of pests and in inhibiting free flow of plant materials from one Partner State to another.

b. Technical Approaches in Clearing Plant Materials at the Station

- When established regulations are followed, little difficulty is encountered in getting essential germ plasm released without a crippling loss of time. There have been some unofficial complaints that materials were not processed fast enough, but this situation has improved in recent months, particularly after visits by the Head of the Quarantine Station to some of the research centers.

c. Time of Termination of USAID Assistance

- The Plant Quarantine Station has critical need of the assistance of a highly qualified pathologist until an East African can be trained to assume the responsibility of Pathologist and Head of the Division. The team believes that the Quarantine Station will cease to perform its function unless USAID or another donor agency provides a highly qualified Plant Pathologist until such time as a highly qualified East African assumes the responsibility. This can be accomplished by permitting the present AID technician one additional tour. (Thus project assistance will be terminated in 1978).

d. Cost of Subproject

USAID	$164,350
EAAFRO	173,820
TOTAL	$338,170

EAST AFRICAN FOOD CROPS RESEARCH PROJECT

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TABLE 1 CONSOLIDATED FINANCIAL SUMMARY

	USAID	EAAFRO[a]	TOTAL BY CATEGORY
	$	$	$
Personnel			
Subproject A-1 (Protein Lab.)	170,000	38,850	208,850
Subproject A-2 (Disease Resistance)	400,000	49,600	449,600
Subproject A-3 (Methodology)	100,000	53,200	1,002,080
Subproject B (Marginal Rainfall)	792,000	210,080	628,200
Subproject C (Sugarcane)	456,000	172,200	186,800
Subproject D (Plant Quarantine)	100,000	86,800	
Sub-total	2,018,000	610,730	2,628,730
Participant Training			
Subproject A-1	28,350	-	28,350
Subproject A-2	95,400	-	95,400
Subproject A-3	38,700	-	38,700
Subproject B	154,800	-	154,800
Subproject C	79,800	-	79,800
Subproject D	58,050	-	58,050
Sub-total	455,100	-	455,100
Commodities			
Subproject A-1	10,400	-	10,400
Subproject A-2[b]	16,700	4,000	20,700
Subproject A-3	5,700	27,400	33,100
Subproject B[b]	82,200	16,000	98,200
Subproject C	64,600	16,850	81,450
Subproject D	6,300	-	6,300
Sub-total	185,900	64,250	250,150
Land and Structures			
Subproject A-1	-	107,780	107,780
Subproject A-2	5,000	2,500	7,500
Subproject A-3	-	194,060	194,060
Subproject B	-	11,780	11,780
Subproject C	-	383,000	383,000
Subproject D	-	20,160	20,160
Sub-total	5,000	719,280	724,280
Travel and Per Diem			
Subproject A-1	-	11,600	11,600
Subproject A-2	-	31,940	31,940
Subproject A-3	-	7,200	7,200
Subproject B	32,000	38,800	70,800
Subproject C	-	31,940	31,940
Subproject D	-	5,720	5,720
Sub-total	32,000	127,200	159,200

TABLE 1 (continued)

	USAID	EAAFRO[a]	TOTAL BY CATEGORY
	$	$	$
Consumable Supplies			
Subproject A-1[c]	3,600	5,700	9,300
Subproject A-2	-	16,000	16,000
Subproject A-3	-	15,000	15,000
Subproject B	-	8,000	8,000
Subproject C	-	88,000	88,000
Subproject D	-	61,140	61,140
Sub-total	3,600	193,840	197,440
GRAND TOTAL	2,699,600	1,715,300	4,414,900

[a]This category includes contributions of Partner States to EAAFRO research program.

[b]This category includes $38,000 for irrigation equipment.

[c]This category includes building modification and house rental for USAID technician.

C. General Conclusions

The proposed Food Crops research project offers a realistic opportunity to assist EAAFRO in assuming a vital role in a research area which has been badly neglected. World recognition of the need for each country to produce to a large portion of its own food needs give great impetus to this project. At the present time East Africa is importing considerable quantities of food to meet needs. Tanzania alone is reported to have spent 1,229 million shillings on food imports between March and September, 1974. With annual population increases in excess of 3 percent, just maintaining present levels of food supply will require a substantial effort. There is universal agreement that proper development of a country depends on the provision of adequate food for the people, not just the production of cash crops for export.

The project proposes a unique role for EAAFRO which permits concentrating resources to accelerate food crop production without duplicating national efforts in related research areas.

Interviews with some 50 East African and international organization officials in Kenya and Tanzania substantiated the usefulness and approval of the 6 proposed subprojects. Disagreements when encountered were centered on location of a proposed facility or alleged inadequacies of the present operations, but not to any great extent on the merits of the proposed subprojects. A preponderance of local opinion in both Kenya and Tanania supports the project as outlined.

There is a general feeling however that these project proposals may represent minimum, not optimum efforts. Great concern was expresssed that support not be termined before the EAAFRO is truly capable of providing the essential total requirements. Ths is particularly a concern, because of the lack of trained personnel available to EAAFRO.

The Food Crops Research Project is viewed as a total package with multiple inter-relationships. Examples include:

- incorporation of opaque-2 and the protein laboratory;
- breeding methodology and probable success in breeding for disease resistance also with incorporation of opaque 2;
- sharing of facilities between marginal rainfall major stations and breeding and trials facilities at Katumani and Ilonga;
- sharing of facilities and Pathologist between sugarcane and maize disease resistance work at Kibaha.

D. General Recommendations of the Team Concerning the East African Food Crops Project

RECOMMEND THIS PROJECT AS INTEGRATED PACKAGE FOCUSED ON FOOD CROPS RESEARCH. A careful examination of the six subprojects reveal an unusual number of interrelated elements between and across projects. Success in each subproject can be tied to the success (or existence) of other subprojects. Therefore, the team strongly recommends approval of the entire Food Crops Research Project for East Africa.

RECOMMENDED LAND-GRANT MODEL. All reserrch units, including EAAFRO, are criticized for their compartmentalized approach and failure to respond to pertinent policy questions. Therefore, it is recommended that recruitment of USAID technicians be conducted with the intention of posting individuals who have experience with the Land-Grant model for research/extension delivery and backstopping.

RECOMMEND GREATER AUTONOMY AND MORE COMPETITIVE SALARY SCHEDULES. For a research unit to remain effective as problems and priorities change it must have capability to change focus and to augment staff at will in support of evolving research focus. The team recommends that USAID support EAAFRO in their efforts to bring salaries in line and to streamline the procedures required for research project approval.

RECOMMENDED INTERACTIVE CAPABILITY BETWEEN RESEARCHER AND RESEARCH DISSEMINATOR. Closest working relationship with potential users of research output fosters credibility and generates research support. Therefore, effective outraach should be encouraged tn EAAFRO by involving naticnal research workers, agricultural planners and extension specialists in the conceptualization, planning, conduct and utilization of research.

RECOMMEND PERIODIC FORMAL PROJECT REVIEW AS DEEMED DESIRABLE BY DIRECTOR OF EAAFRO AND PROJECT LEADER AND AS PREREQUISITE TO TERMINATION. Research productivity in projects of the sort described here can be seriously reduced by premature withdrawal of support before counterpart transition is completed and project objectives are fully realized. Therefore, the team recommends that a formal procedure for review of project status be incorporated in the contract as a prerequisite to termination of support.

RECOMMEND USE OF QUALIFIED CONSULTANTS. Judicious use of qualified consultants can lend critical support for USAID programs and personnel assigned to projects of this sort. The team recommends that provision be made to introduce consultant input to the projects as required for project initiation, review of progress, problem solving, and for staff development.

SUBPROJECT A-1 PROTEIN QUALITY LABORATORY

Conclusions

The establishment of a protein quality laboratory in East Africa is technically feasible and highly desired by the Partner States. It has been requested by all Partner States, and all maize breeders directly concerned have indicated their anticipated participation with an estimated sample volume large enough to fully employ a skeleton staff just as soon as personnel, facilities, and testing equipment can be assembled. The laboratory would be an essential component of at least seven (7) currently active maize breeding stations in East Africa, who are concerned with high quality protein.

Recommendations

The team recommends that an EAAFRO protein quality laboratory be established as requested by the Partner States. With USAID support for a period of four (4) years such a laboratory would become an important integral part of the maize improvement programs of EAAFRO and the Partner States.

The leadership of EAAFRO is capable of giving the needed direction in the operation of the laboratory and its integration with the total maize program. The addition of this facility reaffirms EAAFRO's role of leadership in research which undergirds important national research efforts in the Food Crop area.

The estbblishment of the laboratory would be feasible at a number of East African locations, but the most logical choice appears to be the EAAFRO sub-station at Kitale. The buildings presently available and those planned for construction would be very satisfactory. The required utilities are available and sufficiently reliable. The maize breeding programs of EAAFRO and Kenya located at Kitale would contribute an estimated two-fifths of the initial sample volume. The highly successful maize breeding methodology study would lend prestige to the operation of the laboratory and should facilitate its integration with maize breeding programs in East Africa.

Initially the emphasis would be put on maize because demand is greatest with this crop and the testing procedure is currently available. Analysis of millet and sorghum samples can be added in the future as suitable methodology is more clearly defined and breeding priorities shift to other important food crops.

Since maize is the most important food in much of East Africa, the laboratory, in conjunction with maize breeding programs, would make a very substantial contribution toward improved nutrition for a large portion of the population. This is especially true for those families in low income urban areas who buy maize and for the subsistence maize growers in the high density agricultural areas where substitute forms of protein are too expensive or simply are not available.

The team recommends the establishment of the laboratory of the EAAFRO sub-station at Kitale because of the complement of existing and approved facilities, available utility services, the proximity to the active EAAFRO and Kenyan maize breeding programs, and satisfactory air freight transport.

It is also recommended that a USAID technician with training and experience in protein biochemistry be identified and posted as leader of the project for the four year period, and that two East African counterparts be identified and trained at the laboratory and in the U. S. to effectuate replacement of the USAID technician at the end of the year four (4) of the project.

It is further recommended that provision be established for short term consulting by experts in the protein quality field for periods not to exceed three (3) months per year. Consulting services of this sort will be initiated at the request of the Director of EAAFRO in consultation with the U. S. technician or his counterpart.

SUBPROJECT A-2 BREEDING DISEASE RESISTANCE ON MAIZE

Conclusions

The development by EAAFRO of high quality disease resistant maize populations for use by national breeders in developing varieties for low and medium altitute areas should receive a high priority.

After consideration of several alternate sites, we conclude the EAAFRO program should be headquartered at Kibaha, Tanzania in close proximity to the sugarcane station so that office and laboratory space as well as machinery and other equipment could be shared. Regulations prohibit maize trials on the station proper but not in the area. The climate is reasonably typical of a large part of Tanzania and Kenya lowlands and is favorable for developing the high incidence of streak and other diseases thus permitting effective selection procedures. The fact that the Kibaha station is EAAFRO property will facilitate locating the program in the area.

Since both maize and sugarcane are hosts for streak and sugarcane mosaic, there should be considerable interchange of ideas between the sugarcane station personnel and the maize disease technicians. This gives credence to the location of maize disease work near the Kibaha station. There may be some concern that the diseases of maize will put undue stress on the sugarcane. However, it should be pointed out that there are currently small holders corn patches in the vicinity of the station thus the maize disease trials would not add anything that does not already exist. The maize unit can be located at a distance which is mutually agreeable. Breeding for resistance to streak and other diseases, for improved quality protein, agronomic performance and possibly insect resistance should all be integrated into this program. EAAFRO's primary function in the resistance breeding program would be to establish and stabilize resistance in adapted populations for use by national maize breeders. Close coordination with the subprojects located at Kitale and with the national maize programs of the Partner States is very important.

Recommendations

The team recommends that USAID support the establishment of an EAAFRO maize disease resistance program for the low and medium altitudes.

It is recommended that Kibaha, Tanzania, be the first choice for headquarters for the program.

It is further recommended that in order to get the program started two USAID technicians be supplied. One should be a plant breeder with experience and if possible, some background in plant pathology, to be located at Kibaha. The second would be a plant pathologist with considerable competence in virology to be located at EAAFRO headquarters at Muguga in association with the ODA virologists. His primary responsbility would be to the disease resistance program in working with the breeder in identifying diseases, encouraging epidemics and making selections. He would also be available to consult in the sugarcane breeding program at Kibaha, and to act as a backup for the quarantine technician as well as strengthen the EAAFRO Pathology Division.

SUBPROJECT A-3 MAIZE METHODOLOGY STUDY

Conclusions

The maize breeding methodology study is making a valuable contribution especially to East Africa but also to maize breeding all over the world. Other breeders have studied selection methods singly and in pairs, but the methods investigation being conducted at Kitale under USAID and EAAFRO sponsorship is unique in its wide scope. Nowhere else in the world has such a comprehensive study been made, comparing a number of methods at the same time over a range of environments. However, it is still incomplete and a great deal of its value would be lost by premature termination. It is apparent that the breeding population spin-off has already made a valuable contribution to the breeding programs of the Partner States and is now being used in commercial varieties and hybrid. Capable supporting staff and adequate physical facilities make the continuation of this project feasible and highly desirable.

Recommendations

It is recommended that USAID support of the Maize Methodology Research subproject be continued for an additional two years. This would permit completion of the selection cycles for the major experiments. Evaluation of these experiments would continue.

Since the methodology research would not fully occupy the time of the USAID technician, it is recommended that a limited breeding program to incorporate vitreous endosperm opaque-2 be gradually phased in. Maize populations with improved protein quality, disease resistance and superior agronomic traits would be developed utilizing the improved populations available from the breeding methodology study.

Work on this subproject should be closely coordinated with the proposed protein laboratory and the maize low altitude disease resistance project.

It is recommended that toward the end of two years (1977) a review be conducted to ascertain the feasibility of additional assistance to the vitreous endosperm opaque-2 program which will have been initiated.

No effort should be spared to effectively train East African counterparts.

SUBPROJECT B MARGINAL RAINFALL

Conclusions

Population pressures are forcing unprecedented numbers of people to live in areas where the production of annual food crops is severely limited by lack of available moisture. Estimate of population growth in these areas ranges between 31.1 percent per year to a rate as high as 10 percent. Hard estimates of the land areas involved are not readily available. The magnitude of the problem can be estimated by assuming that the area is that which lies in the 20-30 inch rainfall area. In this area of Kenya about 2,000 square kilometers are being considered for irrigation development projects and 30,000 square kilometers are considered "medium potential" land where production is limited by lack of availbble moisture. Tanzania has expressed an intention to develop 20,000 square kilometers in irrigation projects but the amount of land in marginal rainfall areas suitable for agricultural development does not seem to be determined. However, the intention to use these areas has been dramatized by the decision to relocate the national capital to Dodoma in a marginal rainfall zone. Many of the resettlement villages (Ujamaa villages) are located in marginal rainfall areas. The rainfall pattern tends to shift to a unimodal type in Tanzania and the definition of marginal rainfall areas will be somewhat different from that in Kenya. Not as much attention has been focused upon the Ugandan marginal rainfall area but population pressures there are too forcing development of these areas.

A major conclusion of the study is that large areas of land previously undeveloped because rainfall amounts severely limited crop production are now being opened tosettlement because of population pressures on the land in the highly productive areas of East Africa. These developments are occuring at a high cost and bring on problems such as famine relief and soil erosion. Such problems impose a heavy burden on the society and become more difficult with the increasing scale of the problem.

Recommendations

The study team recommends that USAID support a research program at EAAFRO specifically designed to develop a data base for a more rational extension of agriculture into the marginal rainfall areas of East Africa.

A description of the research project recommended follows:

Basic research on growth characteristics of major food crops to quantify their influences on crop water requirements and on the actual water regime, and to quantify yield responses to water deficits in different growth periods.

Development of the capability to combine data on crop yield responses to water deficits with climatic and soil water measurements to predict the actual water regimes and the consequent crop yield expectations.

Serve as a center for data collection, computation and interpretation. This includes all available meteorological and soils data, plus the research findings at all levels of this and related studies.

Serve in the role of coordination of and liason between all research activities related to food crop production in the marginal rainfall areas by all agencies whether EAAFRO, international agencies, national governments or universities.

Serve as an active disseminator of recommendations for field application of research findings by actively conveying useful information to national planners, research leaders in Partner States and personnel in agencies dealing with development in marginal rainfall areas such as UNDP-FAO, ICRISAT, IITA, World Bank, etc.

Serve as a computation and output center for annual cropping system recommendations based on soil water monitoring at key sites in marginal rainfall areas and on long range weather forecasting.

Inputs that are critical to this research program and should be supplied by USAID include:

Personnel

a. Agrometeorologist/Team Leader - A well qualified technician accomplished in research involving crop response to soil moisture and ability to coordinate persons from diverse disciplines.

b. Agronomist - a technician with experience involving cropping systems in marginal rainfall environments.

c. Agricultural Economist - a technician with research experience in production economics and regional development applications in agriculture.

d. Electronics Equipment Maintenanceman - a technician skilled in maintaining and repairing electronics and regional development applications in agriculture.

Training Functions

Develop expertise in indigenous counterpart personnel by providing opportunities for education in appropriate research specialties and active on-the-job training with accompanying transition to full responsibiltity in the research project.

Facility Development

Specialized equipment required includes the installation of a functional lysimeter and irrigation facilities at Muguga and adequate irrigation capabilities at two National Research centers (at sites to be determined).

Commodities

Equipment including ten class A evaporation pans and four nuclear depth moisture guages. An itemized list is provided in Table 4 of report for subproject B.

Travel

Because the project will be based in Muguga but will require weekly field measurements at six sites in Tanzania and Kenya some technicians will be required to live away from Muguga during the growing season and travel to other sites representative of the marginal rainfall area, travel expense becomes a major factor in support of this subproject.

The study team recommends an evaluation of the methodology of the subproject to ascertain the appropriateness of the research approach to resource development related problems.

The team found fragmentation in research approach at all levels which has contributed to development failures in marginal rainfall lands. For example, it is felt that an aggressive food legume program is necessary but will not be implemented without strong support from the marginal rainfall subproject. In a similar way almost all breeding activities in sorghum and millets have stopped in spite of the fact that they are the cereals most adapted to drought conditions. The extension of research findings into an integrated program that includes technical recommendations appropriately evaluated into the economic and social system mileau in which the farmer operates can be a major contribution and its progress should be monitored and viewed as it impacts marginal rainfall area agriculture.

SUBPROJECT C SUGARCANE

Conclusions

An expanded sugarcane research program to support the existing and developing sugarcane industry in East Africa is essential if the Community is to achieve self sufficiency in sugar production within the forseeable future. All commercial varieties were developed in other countries, particularly India and South Africa. Greatly improved varieties can be developed for East Africa, but EAAFRO requires assistance to develop and maintain an adequate variety program. Also, there are serious salinity problems in several existing areas of the sugar industry and areas have been identified by the Partner States for sugar production that will magnify the scope of this problem. There is no long term research on salinity, compaction, or percolation problems for sugarcane production in East Africa. One or two sugar estates are attempting to determine critical salinity limits but they need assistance from EAAFRO.

There is no research on sugarcane insect problems in East Africa. There are three insects that are causing economic loss at the present time. The most serious problem is white scale (Aulacaspis telalensis) followed by stem borer (Eldana sp) and several species of white grub. EAAFRO will require aasistance in the form of a qualified scientist in order to attack these problems.

The amount of work required by the USAID Agronomist on the variety development program will leave little time to conduct research on cultural practices and management schemes. Either USAID or other donor agency should seriously consider providing a second qualified Agronomist to concentrate on cultural practices and management schemes while an EAAFRO technician is trained to assume the responsibility.

Travel of the EAAFRO sugarcane pathologist stationed at Kawanda, Uganda, has been restricted during the last few years. If this situation continues EAAFRO will require additional assistance to provide a competent sugarcane pathologist to monitor the disease problems in Kenya and Tanzania. It is likely that an expatriate will be needed to provide technical assistance while an East African is recruited and trained. The proposed virologist for the maize disease resistance project could be useful in this area, but it is unlikely that he could carry the entire burden of travel of the sugarcane pathologist, which is severely restricted.

The team is in agreement that USAID should first provide an Agronomist whose principal duties will be on advanced selection and variety testing, and a Soil Scientist whose principal duties will be establishment and supervision of a soils testing laboratory and research on salainity, compaction, and percolation problems. There is a great need, however, for an Entomologist, a second Agronomist, and perhaps a Pathologist if travel of the present EAAFRO Pathologist continues to be restricted. Even with all of the above mentioned scientists, this represents a skeletal sugarcane research program compared to other progressive sugarcane producing areas. It would require a total of 15 to 25 Ph.D.'s with supporting staff in such fields as Breeding, Agronomy, Pathology, Entomology, Biochemistry, Plant Physicology, Agricultural Engineering, Weed Control, and Soil and Water Research to provide adequate technical support for the expanding East African sugar industry. The proposed subproject will strengthen EAAFRO research in variety development and soil and water research and repay the expenditure many times over.

Recommendations

It is recommended that USAID support sugarcane research in East Africa by providing assistance to EAAFRO based on the following priorities:

Supplemental irrigation equipment for the Kibaha Station.

✓Agronomist and supporting equipment stationed at Kibaha to concentrate on advanced selection and variety testing. Assistance needed for four years while an East African is trained to assume responsibility.

Provide qualified consultants for up to three months per year on sugarcane problems as requested by the head of the sugarcane breeding division or by EAAFRO.

Provided funds are available in three or four years, a second Entomologist and supporting equipment stationed at Muguga to work on white scale, stem borer, and white grubs. Assistance needed for four years while East African is recruited and trained to assume responsibility.

Provided funds are available in three or four years, a second Agronomist and supporting equipment to concentrate on cultural practices and management schemes. Assistance needed for four years while an East African is recruited and trained to assume responsibility.

If the current constraints continue for another year on travel of the EAAFRO Sugarcane Pathologist stationed at Kwanda, Uganda, assistance will be needed in providing a sugarcane pathologist to monitor and research disease problems in Kenya and Tanzania.

SUBPROJECT D PLANT QUARANTINE

Conclusions

The team considers the plant quarantine function vital to improvement of food crops in East Africa, and even to continued food production in the Partner States. Many disease and insects pests have a wide host range and can be very destructive on several crops in addition to the one on which they gain entry to an area. Therefore, prevention of entry through an effective quarantine system is a very important part of EAAFRO's responsibilities. It is essential that the East African Community continue a quarantine program and that the program be as effective as possible in excluding harmful diseases and pests. In order to ensure an effective quarantine program it is the opinion of the team that a highly qualified Plant Pathologist must retain the position of Head of the Division. Should a poorly qualified pathologist head the organization or serve as Plant Pathologist the quarantine function is likely to become ineffective either through (1) inadequate screening and detection of pests or (2) recipients becoming thoroughly discouraged with the operation of the quarantine facility with accompanying increase in numbers of illegal entries, i.e., recipients may ignore the quarantine and bring in materials illegally.

The present Senior Horticulturalist could assume increasing responsibility for routine administration, in order to allow the Head more time for work on pathological problems.

The team also felt the educational activities of the current USAID Plant Pathologist have been very helpful in creating an understanding and appreciation by recipients of the need for an effective quarantine. Continued travel throughout the Community to explain the program is urged.

It would strengthen the position of the quarantine service if customs officers were given some orientation on the importance of following plant quarantine regulations. Posters designed to create public awareness of the importance of plant quarantine should be posed in conspicuous places in ports of entry.

Growth rate of sugarcane, at least, is not adequate for detection of some diseases (particularly Sugarcane Mosaic Virus) at the high altitude and low green house temperatures that can be maintained at Muguga. Therefore, a secondary open quarantine facility should be established at a lower elevation, isolated from sugar estates, where growth would be adequate. The primary quarantine should remain at Muguga where imported cuttings would be planted in greenhouses upon entry. After observation and disease testing, cuttings of the healthy plants which develop should be transferred to the secondary open quarantine station, subjected to long hot water treatment and planted as soon after as possible. The quarantine pathologist should periodically inspect the plants after emergence for freedom from diseases, and at 8-10 months of age release healthy plants for distribution by the EEAFRO Division of Sugarcane Breeding. Culture of plants in secondary quarantine would be the responsbility of the Division of Sugarcane Breeding.

The secondary quarantine stations would also be used for initial increase of crops originating from areas free of pests not present in East Africa. A phytosanitary certificate would be required.

Finally the term concluded that the Plant Quarantine Division has done an outstanding job during the past several years, and with the increased facilities now available along with qualified personnel, this function will continue to be an essential part of EEAFRO's mission in protecting and improving agricultural production in East Africa.

Recommendations

It is recommended that USAID continue to assist EAAFRO Plant Quarantine Station by providing needed equipment and a qualified Plant Pathologist to serve as Head of the Division until a suitable candidate completes requirements for a M.Sc. in plant pathology, pursues post M.Sc. training ond on-the-job training under the USAID Plant Pathologist. These goals should be attained by June, 1978.

A second Plant Pathologist trainee should be sent to the U. S. as soon as he can be identified by EAAFRO as a backup. Technical training should be provided for one to three scientific assistants for a period up to one year in such specialized fields as seed pathology, tissue culture, elecoron miscroscopy, serology or other techniques important to plant quarantine work.

Provide opportunity for the USAID Plant Pathologist to attend at least one scientific meeting or seminar each year outside East Africa that deals with subject matter pertinent to plant quarantine, such as virology, plant pathology, or application of specialized techniques.

That EAAFRO establish a secondary open quarantine for sugarcane as detailed in Section III-A of the report on Subproject C. A suggested location is at Morogoro, Tanzania, near the Faculty of Agriculture.

II. PROJECT BACKGROUND

A. Prior Aid Assistance to Food Crop Research

An East African food crops research project was established by USAID in 1963. It was then known as the Cereals and Legumes Project. Its major thrust was the development of adapted varieties of those crops with sorghum and millet being emphasized. Studies were also conducted on management practices and food technology. During the life of the project the following technicians were at post:

3 Plant Breeders (one each for maize, sorghum, and millet)
2 Soil Scientists
1 Virologist
1 Entomologist
1 Food Technologist
2 Field Trials Officers

This project was centered in Serere, Uganda. The suspension of USAID assistance necessitated the withdrawal of personnel from that country. The Food Technologist successfully completed his mission and two trained counterparts were at post when he completed his six year tour on schedule.

The sorghum and millet work was closed out during the period October 1972 to June 1973. Subsequently, in December, 1974, the remaining field trials officer position in Tanzania was abolished.

As of February 1975, the USAID support for tth EAAFRO food crop research project consists of assistance to the plant quarantine station at Muguga, Kenya (1 Plant Pathologist) and to the high altitude maize breeding methodology project at Kitale, Kenya (1 Maize Geneticist).

B. History, Policies and Organization of EAAFRO

The East African Agriculture and Forestry Research Organization (EAAFRO) was established in Nairobi, Kenya, in 1948. It incorporated the East African Agricultural Research Institute which had been located at Amani, Tanzania (formerly Tanganyika). With the advent of the East African community in June, 1967, EAAFRO became a department of the Community and is administratively responsible to the Community.

Within the East African Community (EAC) EAAFRO is a part of the Communication and Research Secretariat and answers to the Research and Social Council on all general policy matters. The research program carried out by EAAFRO is determined by the East African Natural Resources Council. This Council is composed of a Chairman and Deputy Chairman, two representatives of the governments of Kenya and Uganda, three representatives of the government of Tanzania and five scientists. Two of the scientists are local residents; three are overseas scientists. One of the local scientists represents the Universities of East Africa. Two of the overseas scientists are nominated by the Overseas Development Administration of the United Kingdom. In addition to the regular Council members, each Partner State government may appoint two or more advisors to attend council meetings.

EAAFRO headquarters is located at Muguga, Kenya, on a 1,178 hectare estate which is situated some 27 kilometers north west of Nairobi. While its headquarters and several important facilities are located at Muguga, EAAFRO is a decentralized community research organization with substantial research and service activities in Kenya, Uganda, and Tanzania at distances of 20 to 700 miles from the headquarters. A list of major activites together with location and other details are found in Appendix A.

Research Policies

EAAFRO is responsible for undertaking research in the fields of agriculture and forestry on problems that:

- are common to at least two of the East African countries and can be investigated most efficiently and economically by a regional research organization.
- require longer-term investigations or more intensive study than can be undertaken by National Departments.
- require highly specialized and expensive equipment or the services of such specialists as can only be justified on an East African basis.
- are not the responsibility of any other institution in East Africa.

EAAFRO is not concerned with purely local problems unless specifically invited to investigate them by a National Department. Likewise, EAAFRO is not an advisory organization as such, though scientific advise and guidance are readily given by the research staff on request to national and other research workers.

Research requirements are first discussed by the Specialist Research Committees, which may be standing or ad hoc, and which are convened and chaired by EAAFRO specialists. These Specialist Committees are composed of research workers in the appropriate disciplines. The recommendations of these committees are submitted for approval to the appropriate Research Coordinating Committees of which there are four; namely, Agriculture, Animal Industry, Forestry, and Wildlife. These are convened by EAC under the chairmanship of the Deputy Chairman of the East Africa Natural Resources Research Council, and Director of EAAFRO is a member of each committee. Other members are the appropriate Directors or Commissioners of Agriculture and Veterinary Services, the Chief Conservators of Forests and Representatives of the Wildlife Organizations of the three National Governments. The recommendations of the Coordinating Committees are duly considered by the Research Council, but the implementation of the program approved by the Council is dependent on funds being granted by the East African Legislative Assembly.

C. Role of EAAFRO in the Food Crops Research Project

As the regional agricultural research organization, EAAFRO has an important role to play that cannot be handled as economically or efficiently by any of the Partner States. The following are examples of research best performed by EAAFRO:

- Serving as coordinator of an liason between all activities related to food crops research in the East African States. A good example of this kind of effort is the complete management of the East African maize variety trials - which included everything from distributing seed packets to summarization of results at the termination of the trails.
- Serving as the center for data collection, computation, interpretation and dissemination pertinent information and recommendation for various food crops research project. Recommendations for field application of research findings would be made when these findings have reached a stage where they would be useful to Partner States project leaders, planners, and other key personnel.
- Developing maize and sugarcane lines or populations which combine good agronomic characters with satisfactory disease resistance and in the case of maize populations incorporating the vitreous endospern opaque-2 character. These populations would be turned over to Partner States and private breeders for final development and utilization.
- Recommending superior food crop husbandry practices and crop management schemes especially suitable for marginal rainfall areas as well as for maize trials and sugarcane plantings.
- Establishing a high quality protein testing laboratory that will permit breeders to effectively breed and select more nutritional maize.
- Serving as regional plant quarantine station to curtail introduction of new plant pests and to facilitate importation, multiplication and distribution of new germ-plasm.
- Identifying principal viruses affecting maize in East Africa, then screening plant materials from many sources to find resistance which can be used by plant breeders to develop disease resistant lines or populations with desirable agronomic characteristics.
- Continuing to develop an adequate regional library and reference center that can serve scientists in many fields throughout East Africa.
- Maintaining leadership in sponsoring regional seminars and workshops similar to the maize seminars which habe been held for five consecutive years under the sponsorhsip of EAAFRO.
- Serving as an on-the-job training center for East African scientists following completion of academic training - all of the subprojects offer genuine opportunities for young scientists to receive training.

D. Relationship Between EAAFRO and Partner States Research Organization

The primary objectives of EAAFRO are:

(1) To advance knowledge in agriculture, forestry, and allied sciences, the practical application of which will lead to agricultural and forest betterment, reflected in improved and more stable management practices.

(2) To carry out investigations into problems directly affecting aspects of agriculture and forestry.

The national departments of the three countries related to agriculture and forestry are also concerned with similar objectives. Obviously genuine efforts must be made to avoid wasteful duplication and worse, destructive conflict between the Ministries and EAAFRO. The stated policies and outlined administrative procedures are designed by minimize duplication and conflict. The coordinating committee previously mentioned, if properly functioning, can give impetus to programs that complement and support national efforts in the same discipline.

EAAFRO has developed substations strategically located and with a mission to not only place them in close proximity with the national stations but to promote joint endeavors with national scientists. A good example is the maize breeding station at Kitale, Kenya, where the EAAFRO work is carried out on the national station. This appears to be a productive relationship.

In all areas, EAAFRO personnel spend considerable time with national technicians to plan research, discuss results and plan for dissemination of information.

Generally, and particularly in the past, EAAFRO has had a greater number of well trained technicians than the national ministries, thus they have been able to conduct research beyond the capacity of the national organizations. They have been willing to assist Partner States efforts; consequently they have been much appreciated. With more funds and better trained scientists in these ministries complications could occur unless areas for research are very carefully selected.

E. Other Donors, Cooperating Agencies, Institutions and Organizations Conducting Food Crops Research in Africa

Subproject	Donor or Cooperating Agency	Nature of Activity or Support
A-1 Maize Protein Laboratory	IITA/CIMMYT Purdue University	Cooperation in calibration of equipment and in training EAAFRO technicians. Consulting service as requested.
A-2 Maize Disease Resistance	British ODA	Provide sources of resistance and disease resistance screening techniques.
A-3 Maize Methodology	FAO/Egypt CIMMYT/Mexico	Participated in EAAFRO variety trials - (agencies in some 14 countries have participated).
	Kenya Seed Company	Produces and markets maize hybrid seed.
	British ODA	Supports maize agronomy project with Kenya Ministry of Agriculture at Kitale.

Subproject	Donor or Cooperating Agency	Nature of Activity or Support
	Kenya Ministry of Agriculture	EAAFRO maize variety trials.
	Tanzania Ministry of Agriculture	EAAFRO maize variety trials.
	Uganda Ministry of Agriculture	EAAFRO maize variety trials.
	USDA/AID	Consulting service.
B Marginal Rainfall	FAO	Proposed soil survey team based in Tanzania.
	ICRISAT	Negotiating with Faculty of Agriculture, University of Dar es Salaam on cooperative food crops production research.
	Faculty of Agriculture University of Dar es Salaam at Morogora, Tanzania	Provision of land and cooperation of scientist for drought escaping or resistance variety trials - perhaps agricultural economic evaluation and interpretation.
	BRALUP (University Dar es Salaam)	Provide information on land use potential.
	Ministry of Agriculture, Kenya	Proposed Food Crops Research Station. Will perform necessary extension education.
	Department of Water Science and Irrigation, University of California at Davis.	Consultation as needed - training for EAAFRO personnel.
C Sugarcane Breeding	Ministry of Agriculture, Kenya Ministry of Agriculture, Tanzania Ministry of Agriculture, Uganda	Seedling selection and testing.
	Twelve private sugarcane estates in Kenya and Tanzania	Land and labor for variety trials with estimated value of $240,000 (when program is fully implemented).
	Three East African State stations (one in each state)	Land and labor for variety trials with estimated value of $108,000 (when the program is fully implemented).
D Plant Quarantine Station	ODA Virologist	Virus identification. Disease resistance screening techniques. Consultation with station personnel.

F. Previous Work Conducted on Food Crops in East Africa

Maize

Maize improvement research was started by EAAFRO about 10 years ago at Kitale, Kenya, with concentration on developing superior breeding methods for use by plant breeders. It also resulted in the development of long season hybrids which have dominated corn plantings in the highlands.

The type of work at Kitale was later expanded to include a medium maturity program at Embu, Kenya. The major thrust has been to develop hybrids and composites which are better suited to areas of limited rainfall.

The marginal rainfall areas work has been initiated at Katumani, Kenya. Its purpose is to develop short season drought escaping composites. Some potentially useful populations of this sort have also been produced at Kitale.

Significant progress has also been made in purifying maize streak virus and sources of resistance have been found. Similar work has been done with sugarcane mosaic virus. Work continues on other viruses which are of lesser importance but which may in the future constrain production in the low altitude growing areas of East Africa.

The present USAID technician at Kitale has developed some superior cultural practices that demonstrate improved weed control and soil management.

Breeding work to develop maize composites suitable for use in the 1,000 to 2,000 meter altitude areas of East Africa has been in progress in Tanzania since the early 1960's. This kind of work, along with experiments on soil fertility trials and variety trials is currently being carried out by IITA/CIMMYT contract team in Ilonga, Tanzania.

The Faculty of Agriculture of the University of Dar es Salaam is also doing work on cultural practices. They are also developing and testing hybrids using the Ilonga composites as one parent.

All East African countries and some 11 other countries in various parts of the world participate in East African maize variety trials which are conducted under the leadership of EAAFRO.

Sugarcane

Breeding work on sugarcane was initiated in 1966, with emphasis on developing disease resistance clones suited to the sugarcane growing areas of Kenya, Tanzania, and Uganda. The most important diseases are smut and mosaic. Efforts to improve sugarcane prior to this time consisted of importation of some 150 varieties for testing. Two varieties selected from this group are now the major varieties grown in East Africa.

Work at Kibaha, in addition to making crosses and growing seedlings, is directed toward developing techniques for induction and synchronization of flowering. Results from these studies should facilitate the crossing program.

Other than some elementary agronomic, entomological and soils research by sugar estates, there does not appear to be any significant East African based sugarcane research by private agencies. There has been a limited breeding program.

G. Capabilities, Constraints of EAAFRO

Overall, EAAFRO has excellent capability to perform its regional research function:

- The organization enjoys a good reputation with the Natural Resources Council of EAC. Dr. Miguda Alila, Secretary of this Council and a member of the cereal crops project review team, stated that EAAFRO has probably made the greatest contribution in the natural Resources Research efforts.

- The leadership of EAAFRO is well respected. Dr. Majisu the Director and Dr. Wang'ati the Deputy Director are very capable scientists and are dedicated to regional research efforts in support of Partner State endeavors.

- EAAFRO has a good network of research stations and substations located in widely separated areas (20 to 700 miles distant from headquarters at Muguga) thus permitting research trials under varied soil and climate conditions. The stations visited were adequately managed and equipped.

- EAAFRO has adequate budget to permit satisfactory operation of their projects.

H. Constraints

EAAFRO has a dearth of trained scientists. This shortage is especially acute in the field of plant pathology, certain specializations in agronomy, and in agricultural economics.

Substantial assistance from USAID or other donors to supply expatriate scientists who can initiate projects and train local scientists is a continuing necessity. There is also a great need to provide advanced out-of-country training for local scientists who can later replace the foreign advisors.

If EAAFRO is to maintain the capacity to investigate and solve complex problems it must be able to attract superior East African scientists. Satisfactory salaries are a major factor in recruiting and keeping top quality personnel. Currently higher salaries are being paid by universities and the national Ministry of Agriculture in Kenya. Converstion with an official of EAC indicated an awareness of this situation and a desire to alleviate it. There is an agreement by EAC to review the salary situation. When this will actually happen is not known.

It is encouraging to note that in the seminar of January, 1975, organized by the EAC Common Market and Economic Affairs Secretariat, that one of the official recommendations was concerned with salaries as follows:

> "That the existing EAC research organizations be strengthened to serve additional priority functions. Strength can be increased in these organizations by:
>
> Reviewing the terms of service of its research personnel to make them more competitive so that adequate local staff can be recuited and trained."

Since this statement emanated room policy making officials it should have a positive influence.

The lower salary scale, while important, is not the only adverse factor in the personnel situation. There is a general uneasiness that perhaps EAC will not survive or that it will become impotent. Thus well trained people, influenced by this, may elect to accept employment in the universities, the Ministries of Agriculture or in the private sector in preference to working under these uncertainties. On the other hand the prospect of obtaining good people is enhanced by the increasing number of candidates being graduated by East African Universities. Some good prospective scientists are currently obligated to work for EAAFRO upon completion of advanced academic training. Additionally the presence of an esteemed body of productive scientists such as currently exists in EAAFRO serves to attract similar people. Here EAAFRO is in a comparatively strong position. The program which eanbles EAAFRO to obligate young scientists should continue to be supported.

Another situation limiting the effectiveness of EAAFRO is the excessive time required to obtain new project approval from EAC. It is not unusual for six years time to elapse between introduction and final approval. This obviously makes quick response to critical needs quite difficult if not impossible.

One other negative factor is a feeling in Tanzania, though not strongly manifest, that research output todate favors Kenya over the other Partner States. In defense of Kenya, it must be pointed out that all partners have euqal access to the outputs of EAAFRO. Kenya has developed a better capacity to utilize the research results. The "favored Kenya" attitude is not strong enough to weaken EAAFRO's effectiveness. There is Partner State support for solid regional research proposals. The positive reaction in Tanzania fo the six subprojects included in this study provides ample supporting evidence.

There is some feeling that EAAFRO is engaged in too many diverse research efforts and that it should retrench and concentrate on fewer projects. Food crops research has been suggested as an area for major emphasis. The proposed projects if properly supported would strengthen EAAFRO's leadership in food crops research in East Africa.

III. PROJECT ANALYSIS

A. General Statement on Feasiblity Analysis

One of the most significant problems in research planning is involved with feasibility determination and the choices that must be made between (among) projects. The primary justification for planning in advance of project initiation is that this process can elucidate such choices in a manner which is consistent and in the best interests of society at large. Final decisions regarding project choice are generally made in the political arena but this only serves to increase the necessity of providing solid information on feasibility so those decisions do not provide to be counter-productive.

It is also important to recognize that economic feasibility is but one of several necessary conditions for project success. Technical and institutional feasibility are of equal importance and the extent of our acapability to assess them for research projects in advance of their completion is subject to question, and the accuracy of economic estimates of feasibility are directly dependent upon them. However, this problem is mitigated somewhat in agricultural research which has reasonable precedent in other countries or by the availability of similar applications in East Africa which make it possible to guess intelligently concerning potential increments to productivity which can be attributed to a particular research project or proposal for research.

Economic feasibility as employed in the assessment of subprojects which follow was concerned with estimation and comparison of anticipated project costs and benefits and/or determination of potential benefit required to offset estimated costs of the research project.

B. Decision Criteria Used in Determining Feasibilty

- The most efficient (feasible) use of scarce USAID assistance is made if it is utilized in such a way that the amount by which project benefits exceed project costs is maximized.

- A research project should be designed such that each separable subproject can be examined for feasibility to determine whether the benefit it contributes to the overall project at least equal to the cost of the subproject.

- Research projects or facilities such as the protein testing and plant quarantine laboratories should be more economical than any other alternative means for accomplishing the same purpose.

- Feasibility analysis should provide a means for ranking subprojects in a consistent order expressing their desirability.

C. 1. SUBPROJECT A-1 PROTEIN LABORATORY

Purpose

The purpose of the regional protein laboratory is to provide support facilities for maize, sorghum and millet breeders who are attempting to improve protein quality in their plant materials.

Benefits

Benefits assignable to such an installation are typically based on the net savings in cost relative to the cost of obtaining similar services elsewhere. Thus it is necessary to determine the most satisfactory alternative to the project and then make a cost comparison between the existing service and the proposed facility. In the case of the proposed protein laboratory, the alternatives include only the CIMMYT facilities in Mexico and those of IITA in Nigeria. To use either of these facilities would require full payment of costs associated with analyzing the samples plus any transportation costs in addition to what would be required in using the proposed EAAFRO facility in Kitale, Kenya.

Qualitative benefits which may be of greater importance to the breeder are the reduction in probability of losing samples, the shorter turn-around time and the extent to which planting and trials and laboratory capacity can be phased to avoid delay in selections and of protein sample testing. Recent discussions with the Director General of CIMMYT leave this team with the impression that it is their strong preference to locate the proposed facility in East Africa. This preference is based on the current work load at the existing facilities and the superior location advantage relative to active plant breeding stations of the proposed facility. Therefore, it appears that no suitable alternative to the proposed facility exists and for that reason, feasibility is best examined within the context of the question, "What annual net benefit would be required to cause the benefit - cost ratio to equal unity within the useful life of the laboratory?"

Cost

As noted in the report for Subproject A-1, cost of this facility is estimated at $376,280.[1]

Feasibility

The expected life of the laboratory facility is expected to be at least twenty years. Given this time horizon and a discount rate of ten percent (five percent) per annum an annual benefit of $44,000 ($30,000) would permit full recovery of project costs within the life of the facility. It was the judgement of the team that this level of annual benefit will be exceeded with operation of the facility of capacity.

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[1]This estimate covers the cost of placing an operational facility, including personnel on line. It was for this reason that costs in addition to capital costs were included as a part of project costs. Additionally, the cost of labor in years following transition of responsibility to East Africans is ignored.

2. SUBPROJECT A-2 DISEASE RESISTANCE IN MAIZE

Purpose

The purpose of this project is to initiate a maize breeding program at Kibhha, Tanzania, with the objective of incorporating disease resistance into high yielding maize plant populations.

Benefits

Benefits assignable to an effort of this type are predicated on the probability of successful incorporation of resistant characteristics and the quantitative magnitude of damages precluded with full utilization of improved varieties by farmers. Members of the team familiar with similar work in other areas in Africa and the United States have indicated that yield increases in affected regions could range between five and fifteen percent with reasonable success in the breeding effort. It is difficult to construct reliable estimates of maize acreage that would be subjected to disease damage (potential benefit). Some maize breeders in Tanzania have suggested that productivity is seriously reduced by streak and other disease problems on as much as 25 percent of the maize acreage. In Kenya this percentage drips to approximately ten percent but should remain near 25 percent in Uganda. These percentages reflect slightly more than 1,000,000 acres in the three countries. Given that a ten percent increase in current average production could be attained with this project, annual value[1] of damages precluded would range between $4,500,000 and $5,500,000 depending on maize prices. An annual increment of this magnitude for 20 years with discount rate of ten percent would have present value of $42,560,000.

Costs

As shown in the report on Subproject A-2, the cost of this project is expected to total $621,140 over the four years of the project.

Feasibility

Given present value of benefits ($42,560,000) and costs ($621,140) the benefit/cost ratio is 68:1 which far exceeds the minimum unity value required to determine economic feasibility.

3. SUBPROJECT A-3 METHODOLOGY

Purpose

It is the purpose of this project to complete evaluation of the ten year study of maize breeding methodology and to initiate the incorporation of opaque-2 into current lines.

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[1]Since all resources but harvest costs are committed, this value estimates refelects a profit increment if all costs were covered with the lower yields and production increase were not offset with price reduction such that total revenue did not expand.

Benefits

Benefits assignable to a project of this sort are not easily quantified nor are they restricted to a specific geographic or political entity. Primary benefits would be equal to the efficiency gains in maize and other plant breeding work which result because of the existence of a consistently reproducible breeding methodology. Such gains do not conform to any recognizable boundary and defy quantitative estimation. For this reason attention for feasibility determination is limited to an estimation of the annual value required to cause project benefits to offset cost of the project.

Costs

As shown in the report for Subproject A-3, the total cost of this project is expected to be $441,260.

Feasibility

A twenty year time frame with discount rate ten percent (five percent) would require annual net return from the project of $53,600 ($36,600) to cause the present value of benefits to equal project costs. It is the judgement of the team that this value is well within the range of potential benefit which could reasonably be expected from the project and hence in this restricted sense is economically feasible.

4. SUBPROJECT B MARGINAL RAINFALL

Purpose

The prime objective of this subproject is to develop capability for making cropping system recommendations for marginal rainfall areas in East Africa which can be used by governmental agencies in their planning efforts and by farm operators to augment and stabilize their production under conditions of limited and variable rainfall.

Benefits

Benefits created in successful application of this research stem from an ability to cope with limited rainfall conditions by selecting among management options which include planting time, plant spacing, crop and variety selection, probability of rainfall. The extent of benefit is predicated on the frequency and severity of drought and the extent to which cropping systems developed in the research can result in reduced frequency of crop failure and yield reductions of a lesser magnitude. Researchers familiar with marginal rainfall lands in East Africa have indicated that crop failure occurs with twenty percent of plantings and may run as high as forty percent in some areas. In the Partner States, some 100,000,000 acres of land fall within the marginal rainfall classification. Within a twenty year future it is reasonable to assume that an average yield ancrement of twenty-five percent could be expected to occur at least four times. Using maize as an example, the undiscounted value of each occurrence would be in excess of

$25,000,000.[1] Continued expansion of farming into the marginal rainfall areas could result in much greater benefit (potential yield and crop loss).

Qualitative benefits to governmental agencies would occur in the form of increased ability to predict shortages, foreign exchange requirements, input requirements, crop storage requirements and famine relief measures.

Costs

Costs associated with provision of the technical data outputs to be used in making cropping system recommendations are estimated to be $1,345,660.

Feasibility

In the judgement of the team, this project is economically feasible. It must be recognized that such a judgement is rendered within the context of several critical assumptions which may not be warranted.

For this reason, the most conservative estimates of frequency and severity of the occurrence of loss associated with limited rainfall and the capability of the research output to cope with the problems were incorporated into the estimate of benefits, also, since the occurrence of severe rainfall limitation is not subject to prediction, benefit from the project could occur at any time in the future. If a series of drought years occur in early years of the project, discounted benefits will be substantially greater than if the same conditions occurred at some time further into the future. Likewise, if no drought occurs estimates of benefit will be overstated.

5. SUBPROJECT C SUGARCANE

Purpose

This research project is designed to improve the genetic potential of sugarcane and to study soil and crop management practices which restrict yields under East African conditions.

Benefits

Benefits from this project are expected to stem from increased sugar production per acre which is in excess of current average yields. Similar research efforts in other major sugar producing regions of the world have resulted in yield increases of fifteen to twenty

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[1] This estimate assumes current price levels on maize and is based on a ten percent utilization of the marginal rainfall acreage with a twenty percent planting of maize.

percent.[1] It is anticipated that similar yield increases would be forthcoming from this project. In 1974, sugar production was 160,000 and 115,000 metric tons in Kenya and Tanzania[2] respectively. If it is possible to incorporate the anticipated increment of fifteen percent on current production levels, the resultant benefit for a single season would far exceed project costs. A fifteen percent increment on total production in these two countries would have an annual value in excess of $40,000,000 in today's market. Assuming that an annual value of one half this magnitude can be attributed to the project over the next twenty years, the present value of benefit would exceed $170,000,000 when discounted at ten percent. This level of benefit was calculated on current production levels and for plantings in only Kenya and Tanzania. In both countries, very active programs have been established to expand sugarcane acreages by some twenty percent to help offset heavy demands on foreign exchange. If these programs are successfully implemented, the increment of yield increase in excess of the current average could also be attributed to the project.

Costs

Total costs for this subproject are estimated at $1,292,390.

Feasibility

The estimated annual value of the increase in sugar yield is valued at $20,000,000.[3] The present value of this benefit stream discounted at ten (five) percent is in excess of $170,000,000 ($240,000,000). Thus, given the assumptions incorporated into benefit estimates which members of the team have considered to be conservative, this project has a benefit/cost ratio exceeding 100:1, and, therefore, is economically feasible.

6. SUBPROJECT D PLANT QUARANTINE

Purpose

The purpose of the plant quarantine laboratory is to protect crops in East Africa from importation of plant pests of all descriptions and to assist in the introduction, multiplication and dissemination of new germ plasm.

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[1] Yield increases of this magnitude have resulted from various sources. This yield increment is based on an aggregation of the lower estimate of expected increases of three to five percent from development disease resistant varieties and improved management and an additional five to fifteen percent from clone selection for increased yield.

[2] At the time of this review no current data were available on sugarcane production in Uganda. It is anticipated that outputs from the research project would extend to Uganda but for this anaalysis potential benefits from this source were not included.

[3] This amount is a 7½ percent increment on 1974 production levels in Tanzania and Kenya valued at current world prices.

Benefits

Benefits assignable to this project are based on maintenance of the capability to prevent or reduce the magnitude of potential damage to crops and the reduction in effort and cost associated with introduction, multiplication and dissemination of new germ plasm to plant breeders. Earlier experiences in East Africa, such as the inadvertent introduction of Cassava mite, serve to demonstrate the very substantial benefits (damages precluded) which can be associated with this subproject. An investment in the maintenance and further development of the capabilities of this facility should increase the probability of avoiding future introductions of this sort. Additionally it is anticipated that the cost, effort in obtaining materials and the knowledge of availability of new germ plasm for the several plant breeding units throughout the region will be benefitted by the greater emphasis placed on plant introduction, increase and dissemination in the outline of this subproject. These potential benefits are significant but defy quantitative treatment. For this reason, analysis of economic feasibility is restricted to estimation of the annual benefit required to cause the value of discounted benefit to be at least equal to project costs.

Costs

The estimated total costs of this subproject are expected to be $338,170.

Feasibility

Given a twenty year time horizon and assuming a discount rate of ten (five) percent, an annual benefit stream of approximately $40,000 ($28,000) would be required to be assured that this subproject is feasible. In the judgement of the team a very minor introduction of disease or pests would result in damages (benefits) far in excess of this amount.

APPENDIX A

EAAFRO RESEARCH AND SERVICE ACTIVITIES RELATED TO THE FOOD CROPS RESEARCH PROJECT

PLANT PATHOLOGY AND NEMATOLOGY

Location:	Based at Muguga, Kenya
Staff:	Research Officers (4) Scientific Assistants (2) Laboratory Assistants (2) Subordinate Staff (3)
Programs:	Identification of virus diseases of food legumes and cereals. Nematode diseases of food and cash crops. Support to other EAAFRO divisions, especially sugarcane pathology.

PHYSICS AND CHEMISTRY

Location:	Based at Muguga, Kenya
Staff:	Research Officers (7) Scientific Assistants (5) Laboratory Assistants ( ) Subordinate Staff (10)
Programs:	Water catchment area research. Ground water studies. Studies on water requirements of crops. Tillage studies -- mainly support for national government experiments. Soil calibration studies for improved basis of fertilizer recommendations. Service analysis of soil and plant materials for national departments without the necessary equipment.

PLANT PYSIOLOGY

Location: Based at Muguga, Kenya

Staff:
Research Officers (2)
Scientific Assistant (1)
Laboratory Assistants (5)
Subordinate Staff (8)

Programs: Drought escaping and adaptation mechanisms.

SORGHUM AND MILLETS

Location: Based at Serera, Uganda

Staff:
Research Officers (5)
Scientific Assistants (7)
Subordinate Staff (4)
Others (10)

Programs: Breeding, agronomy, entomology of sorghum, finger-millet and bulrush-millet.

MAIZE GENETICS

Location: Kitale, Kenya

Staff:
Research Officer (1)
Scientific Assistants (2)
Laboratory Assistants (4)
Subordinate Staff (12)

Programs: Testing new varieties for field resistance to diseases before release, yield loss assessment trials.

PLANT QUARANTINE SERVICE/RESEARCH

Location: Muguga, Kenya; Completely centralized

Staff:
Research Officers (2)
Scientific Assistants (2)
Laboratory Assistants (5)
Subordinate Staff (10)

Programs: Processing and distribution of plant material, rapid propogation techniques.

STATISTICS SERVICE

Location: Muguga, Kenya

Staff: Research Officers (2)
Scientific Assistant (1)
Laboratory Assistant (1)

Programs: Design, analysis and interpretation of field experiments.

AGRICULTURAL MACHINERY COORDINATION (SERVICE)

Location: Based at Muguga, Kenya

Staff: Research Officer (1)

Programs: Collecting and adapting findings in agricultural machinery research in East Africa. Coordination of work of this kind throughout East Africa.

SCIENTIFIC LITERATURE AND LIBRARY SERVICE

Location: Muguga, Kenya

Staff: Officers (7)

Programs: Maintenance of library, photocopying service to more than 160 stations in East Africa.

A P P E N D I X B

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Mr. David Sperling	Maize Breeder, Ilonga Research and Training/ Kiloso, Tanzania

APPENDIX C

ITINERARY

JAN. '75 ← FEBRUARY 1975

	Th	F	Sa	S	M	T	W	Th	F	Sa	S	M	T	W	Th	F	Sa	S	M	T	W	Th	F	Sa	S	M	T	W
	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Dr. Ballard** (Team Leader)	NBI	EAA NBI	EAA	← Dar/Morogoro/Ilonga →						CA	← Arusha →		NBI	NBI	NBI	EAA	NBI	← Kitale →			NBI	NBI	NBI	NBI	NBI	EAA	NBI	NBI
Dr. Fullerton (Agro-Economist)	NBI	EAA EAC		← Dar/Morogoro/Ilonga →						CA		← E A A → ← E A C →		NBI	NBI	EAA	NBI	NBI	NBI	NBI	NBI	NBI	NBI	NBI	NBI	EAA	NBI	NBI
Dr. Stewart (Agro-Met.)	NBI	← EAAFRO →			← EAAFRO/Muguga →					CA		← E A A →		NBI	NBI	EAA	NBI	To US										
r. Crane i. Protein Lab.	NBI	← EAAFRO →			EAA	← Kitale →						← E A A →		NBI	NBI	EAA	NBI	To US										
Dr. Wood (Breeder/Path.)	NBI	← EAAFRO →		← Dar/Morogoro/Ilonga →						CA		← E A A →		NBI	NBI	EAA	NBI	NBI	← E A A →		NBI	NBI	NBI	To US				
r. Arny (Breeder Path.)	NBI	Disease Resist. Maize			EAA	← Kitale →						← E A A →		NBI	NBI	EAA	NBI	NBI	EAA	NBI	NBI	NBI	To US					
r. James (Sugar Cane)		← EAAFRO →		← Dar/Kibaha/Moshi →						EAA	← Kisumu →			NBI	NBI	EAA	NBI	To US										

NOTES:

NBI – Nairobi Office
EAA & EAAFRO – East African Agriculture and Forestry Research Organization -- Muguga
CA – Charter Airplane to overfly marginal rainfall area in Kenya and Tanzania
EAC – East African Community Statistical and Economic Department, Nairobi.

**Ballard arrived in Washington January 23, who was briefed on January 24, and departed for Nairobi arriving January 26 - The period January 26 to January 30 was spent in making arrangements to facilitate team work. The balance of the team were briefed in Washington January 28 - they arrived in Nairobi January 30.

STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT A1 - REGIONAL PROTEIN QUALITY LABORATORY

I. BACKGROUND

A. PAST

Since the discovery at Purdue University in 1964 that the opaque-2 maize mutant contains higher levels of the essential amino acids, lysine and tryptophan, the improved nutritional value of its protein has been well established for humans and non-ruminant animals.

Maize is the most important food crop in Tanzania and Kenya, and one of the most important in Uganda (Tables 1 & 2). In the highlands, maize is grown primarily as a commercial crop, while in the lowland areas it is usually grown as a subsistence crop. Much of the commercial maize is sold to the urban population. Both the low income urban sector and the lowland subsistence farmer who is dependent on cassava and cereal protein would benefit greatly from improvement in maize protein quality.

B. PRESENT SITUATION

1. Success to Date:

Conversion of breeding populations to opaque-2 versions has been initiated in the Kenyan national program at Kitale, in the Tanzanian national program at Ilonga, and the Ugandan national program at Kawanda. Conversion to maize of improved protein quality is also scheduled for the Embu and Katamani stations in Kenya in the near future. However, all these are without benefit of a protein quality laboratory. All Partner States have requested EAAFRO to establish such a laboratory. Experiment stations that have indicated support for this facility and the number of samples they intend to send to the laboratory include: Ilonga Research & Training Institute, Kilosa, Tanzania (2,000 probable samples per year); Kawanda Research Station, Kampala, Uganda, (2,000 probable samples per year); Kenya National Agricultural Research Station, Kitale, Kenya (1,500 probable samples per year); Embu Agricultural Research Station, Embu. Kenya (500 probable samples per year); Katumani Agricultural Research Station, Machakos, Kenya (500 probable samples per year); Maize Genetics Division, EAAFRO, Kitale, Kenya (2,000 probable samples per year); The Faculty of Agriculture and Forestry, Department of Crop Science & Production, University of Dar-es-Salaam, Morogoro, have also indicated interest and support for this facility especially if capability can be expanded to include millets, sorghum and rice. In addition it is estimated that Ethiopia, Malawi and Zambia could generate as many as 1,000 samples per year on a cost basis.

TABLE 1

Acres, in millions, sown to the major cereals in East Africa

Country	Maize	Sorghum	Bulrush Millet	Finger Millet	Total
Kenya	3.0	0.5	0.3	0.3	4.1
Tanzania	2.0	1.2	0.7	0.4	4.3
Uganda	0.5	0.8	-	1.3	2.6
TOTAL	5.5	2.5	1.0	2.0	11.0

(a) From: East African Major Cereals Project Evaluation. USAID. 15 Sept., 1972

TABLE 2

Maize: Past and Future Total Production in metric tons (ECA & FAO, 1971)

	Production in 1,000 metric tons		
Year	Kenya	Tanzania	Uganda
1964-66	1,242 (-84)[a]	751 (+5)	226 (+17)
1970	1,560 (+37)	900 (0)	330 (-50)
1975	1,890 (+64)	1,070 (0)	345 (-36)
1980	2,400 (+105)	1,280 (0)	371 (0)

a) numbers in bracket denotes surplus (+) or deficit (-) in relation to demand for maize.

Other protein quality laboratories do exist, most notably those of CIMMYT in Mexico and IITA in Nigeria, neither of which is easily accessible to the maize breeders in East Africa.

2. Constraints:

In maize the opaque-2 mutant characteristically has soft, chalky endosperm in most genetic backgrounds. Hard or vitreous endosperm is neccessary for consumer acceptance in East Africa. In the presence of opaque-2 there are some modifier genes which contribute to a harder endosperm. Some of these modifiers result in lower levels of lysine and tryptophan analyses. At present, no facility for analyzing for these amino acids is available in East Africa.

The laboratory at CIMMYT serves their own breeding programs and provides limited service to Mexico and other Latin American breeding programs. However, it is not prepared to analyze samples from numerous breeding programs, as evidenced by the fact the CIMMYT is assisting Colombia and Peru to set up their own laboratories on the same general plan as that proposed by EAAFRO. Delay in getting test material to Mexico and analysis data back would seriously hamper selection programs. Breeders in East Africa have expressed doubt whether samples could be sent to a center such as IITA where the importation complications are unpredictable and test results could not always be obtained in time for selection in the next generation.

In maize, total crude protein determination alone is of limited value. Approximately 40 percent of the protein in normal maize is not useful to humans or nonruminant animals, while an increase from 2.5 and 0.5 to 4.0 and 1.0 percent of the protein as lysine and trytophan, respectively, can result in a three-fold increase in the rate of gain by weanling rats. The excellent nutritional qualities of opaque-2 have also been confirmed for children in Colombia and Guatamala, and for adults in the U.S. with problems of protein deficiency.

Analysis of millet samples can be added without difficulty when suitable methodology is determined. In grain sorghum, the protein nutritional value is dependent both on the levels of lysine and tryptophan and on the levels of interfering tannic acids. Therefore, analyses of both the limiting amino acids and the tannic acids are necessary. Simple analytical methods for tannic acids are now being developed under the sponsorship of USAID in the grain sorghum project at Purdue University.

To date, no simple method of analysis of the limiting amino acid, methionine, in legume seeds has been developed. But when such methods are developed, the analysis of legume seeds could undoubtedly be phased into operation at this facility.

3. Other Agencies or Donors:

No other agencies or donors are directly involved in East Africa, but IITA, CIMMYT and Purdue University would form valuable backup support by analyzing check samples to test calibration, by consultation, and by aiding in training personnel.

4&5. Relationships between EAAFRO and National Research Programs:

Each of the Partner States has requested that EAAFRO establish a protein quality laboratory to assist maize breeders in the selection of germplasm with high levels of the amino acids, lysine and tryptophan. The breeders have confirmed their interest in using the services of such a facility, have assured their cooperation and have estimated their number of samples as indicated in item 1 above. The EAAFRO technician would serve as consultant for national breeders, particularly in the interpretation and utilization of results in their respective breeding programs.

6. Previous Studies in this Area of Work:

Simplified methods for the analysis of total protein, lysine and trytophan have been developed, especially to serve breeding programs for improved protein quality in cereal grains. These methods require minimal equipment and straightforward procedures as described by Villegas and Mertz in CIMMYT Res. Bull. No. 20, May 1971. These procedures are being used in the service laboratory established by CIMMYT in Mexico.

7. Views of the Subproject Team Regarding EAAFRO'S Capabilities:

It is the judgment of the team that EAAFRO, with the 4 year assistance of a USAID technician, would be fully capable of the successful operation of a protein quality laboratory. Dr. Majisu, Dr. Wang'ati, director and deputy director of EAAFRO respectively, and Dr. Ogada, director of the Kitale station, provide capable leadership and all of them have a realistic conceptualization of the relationship between the breeding programs and the protein testing laboratory.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1. Subproject Objectives:

a) To establish in EAAFRO a Protein Quality Laboratory for the support of programs working on maize varieties and hybrids for improved protein quality in the Partner States of Kenya, Tanzania and Uganda. Analyses would also be provided to other countries in Eastern Africa on a cost basis. Initially, analyses would be exclusively on maize, but as methods are more clearly defined elsewhere, at least the millets and sorghum would be included.

b) To provide coordination and consultation with national and EAAFRO breeders in the interpretation and utilization of the laboratory data obtained.

2. Subproject Relationship With Other Subprojects:

a) The activities of the laboratory would be closely integrated with the subprojects on maize breeding methodology as opaque-2 is introduced into some of the populations and with breeding for disease resistance and protein quality in low altitude maize.

3. Technical Feasibility of the Project as Designed:

a) The procedures to be used in the laboratory have been well worked out and tested by Villegas and Mertz, and have been accepted by maize breeders at a number of institutions. The climate at Kitale is similar to that of Mexico City, so that there should be no adverse effects from this source. The procedures employed are relatively simple and can be learned in a reasonably short time by a qualified trainee. The instruments used are not highly sophisticated and critical spare parts will be supplied. Repair service is available in Nairobi.

With these considerations and the availability of laboratory space and essential utilities, the operation of the laboratory will be technically feasible.

b) Justification for Kitale location - There are several possible sites in East Africa for the location of the protein laboratory. However, a primary reason for the choice of Kitale is that EAAFRO's highly successful maize breeding program is there. Cooperation, consultation and integration on matters of project planning, distribution of work for the protein lab, planting of trials and the joint use of facilities between the staffs of the two projects would be highly beneficial. Also approximately 40% of the samples to be enalyzed in the initial year will be generated there by the EAAFRO and Kenyan breeding programs located in Kitale.

Secondarily, temporary laboratory space has been made available by the station director, and the station has been designated as a sub-station of EAAFRO. EAAFRO has the authority and plans have been completed for the construction of a permanent office/laboratory facility as well as housing for the staff of this project. The office/laboratory building will serve both the maize breeding methodology program and the protein laboratory and will provide very adequate facilities (see floor plan sketch in Appendix B-1).

The basic utilities, water and electricity, as well as telephone are available and reasonably reliable. Transport of samples to Kitale may be somewhat of a problem, but a significant portion of the samples will be generated at Kitale. In previous years it has been possible to cope with the transport problem in the case of seed sent out for the East African Maize Variety trial each year. Scheduled air service which carries freight is available several times a week at Kitale.

4. Beginning and Ending Points With Intermediate Targets For USAID Assistance: (See Table 3).

a) Year 1: The arrival and posting of USAID technician, including a visit to CIMMYT in Mexico; purchase and installation of laboratory and office equipment; support of travel and six-week training at CIMMYT for Senior Laboratory Assistant.

b) Year 2: Begin 12 month technical training in U.S. of two counterparts (Purdue University suggested).

c) Year 3: Complete U.S. training and training at CIMMYT of counterparts (Laboratory Technicians). In-service training upon return.

d) Year 4: Completion of USAID commitment; transition to full responsibility by one of the counterparts.

5. Importance to the Development of Food Crops in East Africa:

It is obvious that if the nutritional status of low income maize consuming families in East Africa, whether they are urban dwellers, or subsistence farmers, is to be upgraded, there is need to expand and accelerate research efforts to produce adapted high quality protein maize varieties that will be readily accepted. A crucial part of this research effort is a facility capable of testing for the limiting essential amino acids, lysine and tryptophan, in breeding materials as they are being developed. This is particularly true because in selecting for the vitreous kernel character necessary for consumer acceptance, the breeder can no longer select from the opaque-2 character visually, and without analysis could lose the quality factor very quickly.

With the population expanding at rates in excess of 3% per year in East Africa, food supplies must increase in quantity as well as quality. Increased yielding capacity of improved maize varieties and hybrids will probably provide the main contribution to this needed increase. With the laboratory, the protein quality of the improved varieties can be upgraded also.

Some suggest that it would be easier and probably cheaper to supplement maize meal with the required amount of lysine and tryptophan as it is milled. This would be useful for urban dwellers who buy their meal, but would be of no help to subsistence farmers who depend upon village processing of maize. The distribution system of much of East Africa is such that it would be impossible to get enriched meal to the farmers.

CIMMYT Researchers in Tanzania have indicated that in taste tests comparing opaque-2 with traditional varieties of maize in a number of villages, a majority of subjects favored the opaque-2. As a more vitreous endosperm is developed, it is expected that storage losses typically associated with opaque-2 will be reduced. Thus the taste and storage characteristics of maize with improved protein quality may not be important constraints to consumer acceptance in East Africa.

In addition to the above considerations, it is apparent that with the combination of programs in maize breeding for high and low altitudes and disease resistance, the additional complement of a protein laboratory should establish EAAFRO in a strong position of leadership for maize research in East Africa for the forseeable future.

B. EXPECTED OUTPUTS

1. Basic Assumptions Required for Success:

a) That a demand presently exists for protein quality analyses in sufficient volume (see section I b1) and will continue in EAAFRO and the national maize breeding programs of the Partner States.

b) Demonstration of willingness to cooperate among all concerned. These include the national corn breeders at Ilonga, Tanzania, in Uganda, and at Kitale, Embu and Katumani Stations in Kenya as well as the EAAFRO program at Kitale and the Faculty of Agriculture at Morogoro, Tanzania. Breeders in Ethiopia, Malawi and Zambia have also indicated interest.

c) That a maize of acceptable grain type, i.e. reasonably vitreous, and with improved lysine and tryptophan content can be developed.

d) That the office/laboratory building will be completed by EAAFRO by July 1, 1976.

e) That an East African counterpart to USAID technician can be identified and trained in a manner which permits his assumption of full responsibility of laboratory by the end of year four.

f) That techniques for protein quality testing in millets and sorghum can be generated within a time frame which permits their incorporation in the project.

2. Predicted Benchmarks of Achievement: (See Table 3)

a) Year 1: Begin protein testing of maize samples from Partner States and EAAFRO; initiate on-the-job training for two Laboratory Technicians counterparts, send Senior Laboratory Assistant to CIMMYT laboratory in Mexico for six weeks training.

b) Year 2: Bring maize testing capability to full capacity; begin protein testing on millets; send counterparts to U.S. for special non-degree training (Purdue University suggested); initiated meeting with national breeders to discuss interpretation of results and the capabilities of the facility.

c) Year 3: Continuation of maize testing as demand dictates; encourage increased use from millet breeders if procedures developed in year 2 are reliable; begin sorghum testing if suitable methods are available; resumption of on-the-job training by counterparts upon completion of training in U.S. and at CIMMYT: initiate technician visits to all breeding stations in the Partner States who have participated in protein testing to interpret results and to determine future demand for testing facility.

d) Year 4: Maintain full capability for maize and millets and for sorghum if possible; phase in tests for total protein in other grains; assumption by counterparts of full responsibility for operation of laboratory; conduct a second meeting with national breeders from Partner States and other interested countries to discuss interpretation of results and to exchange ideas concerning capabilities in maize, millet and sorghum testing and the logistics of utilizing the services of the facility.

3. Predicted Impact at End of USAID Assistance:

At the end of USAID assistance full responsibility for the operation of the laboratory will be with trained East African personnel. The USAID technician, in cooperation with EAAFRO maize breeder, will have met with national breeders for discussions concerning interpretation and further application of analyses and to review progress toward high quality protein maize. The technician also will have visited breeders at their home stations in order to become familiar with local conditions and discuss problems.

Progress in the EAAFRO and national maize breeding programs toward the conversion of maize populations to opaque-2 will have benefited to the extent that a protein testing facility in close proximity to the breeding stations increases the consistency, reliability and timeless of results.

III. REQUIRED INPUTS

A. EAAFRO CONTRIBUTION

1. Personnel:

a) Two Laboratory Technician counterparts (B.Sc. in Chemistry).
b) One Senior Laboratory Assistant (Diploma).
c) One or two Laboratory Assistants (School Certificate), depending on volume of work.
d) One clerical officer (Stores).
e) Joint use with maize breeder, or existing secretary. May require one full time later.

2. Capital:

a) Laboratory/office building to be completed by July 1, 1976, at cost approximately $200,000.
b) House for USAID technician to be completed by July, 1976 at ~~cost of~~ approximately $20,000.
c) House for Laboratory Technician at approximately $8,500.
d) Houses for Laboratory Assistants and Clerical Officer $6,400.
e) Remodeling of temporary laboratory at cost of approximately $1,200.00

3. Financial Support:

a) Salaries of EAAFRO Staff:

Laboratory Technician	-	$ 2,400	per year
Senior Laboratory Assistant	-	$ 1,500	" "
Laboratory Assistant	-	$ 1,092	" "
Clerical Officer	-	$ 1,092	" "
Stenographer (1/2)	-	$ 800	" "

b) Recurrent expenditures:
Consumable supplies following exhaustion of initial stocks.
c) Within East Africa travel and per diem of EAAFRO staff and travel for USAID technician.

4. Training:

Furnish two Laboratory Technicians as counterparts to USAID technician for training in the U.S.

5. Commodities:

See item 3b above.

TABLE 3

TIME PHASES FOR ACTIVITY ACHIEVEMENT
REGIONAL PROTEIN QUALITY LABORATORY

ACTIVITY	YEAR 1 Q1 Q2 Q3 Q4	YEAR 2 Q1 Q2 Q3 Q4	YEAR 3 Q1 Q2 Q3 Q4	YEAR 4 Q1 Q2 Q3 Q4	YEAR 5 Q1 Q2 Q3 Q4
A. Development of Physical Facility	24	mos			
1. Modification of temporary laboratory	6 mos				
2. Construction of office/laboratory	18 mos				
3. Construction of housing	18 mos				
B. Staff Recruitment, Development and posting			60 mos		
1. Identification and posting U.S. Technician a/	6-9 mos				
2. Identification and posting of counterpart East Africans (2) (Laboratory Technicians)	12 mos				
3. On-the-job experience/training for counterparts		6-8 mos			
4. Technical training in US for counterparts		12	mos		
5. Technical training at CIMMYT for counterparts			3 mos		
6. Transition of responsibility from US Technician to counterpart				15 mos	
7. Identification and CIMMYT training of Senior Laboratory Assistant	6 weeks				
8. Identification and posting of first Laboratory Assistant	6 mos				
9. Identification and posting of second Laboratory Assistant			6 mos		

Table 3 (contd.)

ACTIVITY	YEAR 1 Q1 Q2 Q3 Q4	YEAR 2 Q1 Q2 Q3 Q4	YEAR 3 Q1 Q2 Q3 Q4	YEAR 4 Q1 Q2 Q3 Q4	YEAR 5 Q1 Q2 Q3 Q4
C. Testing Capability		Continuous throughout useful life of the facility			
1. Maize protein and tryptophan			Same		
2. Millet protein and tryptophan				Same	
3. Sorghum Protein and tryptophan				Same	
4. Crude Protein for other grains b/				Same	
D. Duration of USAID Project Support c/		48	mos		

a/ Full job description for this individual is included in Appendix A.

b/ Analyses of this sort will be conducted but will be accorded secondary priority.

c/ Note that project initiation and termination dates span 48 months. Initiation date is coincident with posting date of the U.S. Technician.

TABLE 4

TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR REGIONAL PROTEIN QUALITY LABORATORY

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Personnel a/										
(1) USAID technician	50,000	40,000	40,000	40,000	170,000	-				
(2) Laboratory technician counterpart	4,800	4,800	4,800	4,800	-	19,200				
(1) Senior Lab. Assistant	1,500	1,500	1,500	1,500	-	6,000				
(2) Laboratory Assistants	550	1,100	2,200	2,200	-	6,050				
(1) Clerk	1,100	1,100	1,000	1,100	-	4,400				
(½) Stenographer	800	800	800	800	-	3,200				
Participant Training										
(2) Laboratory technicians to the U.S. for 12 months b/		10,350	10,350		20,700	-				
(2) Laboratory Technicians to CIMMYT for 3 months			5,000		5,000	-				
(1) Senior Lab. Assistant to CIMMYT for 6 weeks	2,650				2,650	-				
Commodities c/										
Laboratory equipment & chemicals	9,000				9,000					
Office equipment	1,400				1,400					
Land & Structures										
(1) Senior staff house	10,000	10,000				20,000				
(1) Intermediate staff house	4,500	4,000				8,500				
(3) Junior staff house	3,000	3,400				6,400				
Office/laboratory facility	35,000	35,000				70,000				
Building site approx.2 ac.	720	720	720	720		2,880				

Input	Time and Cost				Total by Category					
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Consumable Supplies and Maintenance	500	1,000	1,500	1,500		4,500				
<u>Travel and Per Diem</u>										
Outside East Africa	1,450	1,450	1,450	1,450		5,800				
Within East Africa	1,450	1,450	1,450	1,450		5,800				
<u>Miscellaneous</u>										
Modification of temporary Labs.	1,200					1,200				
House Rental	1,800	1,800			3,600					
TOTAL FOR PROJECT					212,350	163,930				

a/ A three to six week period of time will be spent at CIMMYT to become familiar with their equipment and methods if such experience has not already been acquired.

b/ This item includes travel to and from the U.S. and financial assistance.

c/ Detailed commodity lists are attached in Appendix A.

B. USAID CONTRIBUTION

1. Personnel:

Technician (M.Sc. biochemist or B.Sc. with experience - see job description Appendix A-1) for four years at a cost of $50,000 first year, $40,000 subsequently.

2. Commodities:

a) Office and laboratory equipment and initial stock of supplies (See lists in Appendix A-2).

3. Financial Support:

Rent of house in Kitale for technician will be required until EAAFRO house is completed about 1 July, 1976, at cost of approximately $300/month.

4. Participant Training:

a) One year of U.S. training for counterpart Laboratory Technicians at Purdue University at $10,350 each.
b) Senior Laboratory Assistant training at CIMMYT for 6 weeks $2,650.

5. Time Phase for Inputs:

See Table 4

IV. CONCLUSIONS & RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

The establishment of a protein quality laboratory in East Africa is technically feasible and highly desired by the Partner States. It has been requested by all Partner States, and all maize breeders directly concerned have indicated their anticipated participation with an estimated sample volume large enough to fully employ a skeleton staff just as soon as personnel facilities and testing equipment can be assembled. The laboratory would be an essential component of at least seven (7) currently active maize breeding stations in East Africa, who are concerned with high quality protein.

The leadership of EAAFRO is capable of giving the needed direction in the operation of the laboratory and its integration with the total maize program. Addition of this facility reaffirms EAAFRO's role of leadership in research which undergirds important national research efforts in the Food Crop area.

The establishment of the laboratory would be feasible at a number of East African locations, but the most logical choice appears to be the EAAFRO sub-station at Kitale. The buildings presently available and those already approved for construction would be very satisfactory. The required utilities are available and sufficiently reliable. The Maize breeding programs of EAAFRO and Kenya located at Kitale, would contribute an estimated two-fifths of the total. The highly successful maize breeding methodology study would lend prestige to the operation of the laboratory and should facilitate its integration with maize breeding programs in East Africa.

Initially the emphasis would be put on maize because demand is greatest with this crop and the testing procedure is currently available. Analyses of millet and sorghum samples can be added in the future as suitable methodology is more clearly defined and as breeding priorities shift to other important food crops.

Since maize is the most important food in much of East Africa, the laboratory in conjunction with maize breeding programs would make a very substantial contribution toward improved nutrition for a large portion of the population. This is especially true for those low income families in urban areas who buy maize and for the subsistence maize growers in the high density agricultural areas where substitute forms of protein are too expensive or simply not available.

B. RECOMMENDATIONS

The team recommends that an EAAFRO protein quality laboratory be established as requested by the Partner States. With USAID support for a period of four(4) years such a laboratory would become an important integral part of the maize improvement programs of EAAFRO and the Partner States.

The team recommends the establishment of the laboratory at the EAAFRO substation at Kitale because of the complement of existing and approved facilities, available utility services, the proximity to the active EAAFRO and Kenyan maize breeding programs, and satisfactory air freight transport.

It is also recommended that a USAID technician with training and experience in protein biochemistry be identified and posted as leader of the project for the four year period, and that two East African counterparts be identified and trained at the laboratory and in the U.S. to effectuate replacement of the USAID technician at the end of year four (4) of the project.

It is further recommended that provision be established for short term consulting by experts in the protein quality field for periods not to exceed three (3) months per year. Consulting services of this sort will be initiated at the request of the director of EAAFRO in consultation with the U.S. technician or his counterpart.

JOB DESCRIPTION OF USAID PROTEIN LABORATORY TECHNICIAN

TRAINING

M.Sc. or B.Sc. with considerable experience in protein biochemistry. A familiarity with the various analytical procedures for protein and amino acids are essential.

EXPERIENCE

Two years of experience in protein biochemistry including analytical procedures for protein and the various amino acids. Some experience in the care, maintenance and minor repair of such laboratory instruments as pH meters, colorimeters, centrifuge and balances. Maturity in the candidate is desired - well qualified retirees will be given full consideration.

DUTIES

Provide leadership in the establishment and operation of a new Protein Quality Laboratory in East Africa. Duties also include the training of laboratory assistants and facilitation of a transfer of full responsibility for the laboratory to an East African counterpart. The technician will be in charge of the analysis of maize, millet and sorghum (possibly other grains or legume seeds at a later date), particularly for total protein by micro-kjeldal and tryptopahn by the Opienska-Blauth colorimetric method as modified by Hernandez and Bates, but also including less frequent analyses for lysine by the colorimetric method developed by Tsai and modified by Villegas.

Assist the breeders in planning the scheduling of their submission of samples in order to distribute the analytical work-load as evenly as possible throughout the year. Consult with the breeders in the interpretation and utilization of the laboratory data.

SALARY

Competitive, negotiable.

Protein Laboratory Equipment

Supplier: Sergent-Welch Scientific Company

Address: 7300 N. Linder Avenue, Skokie, Illinois, 60076 - USA

Quantity	Catalogue Number	Description	Unit Price	Total Price US $
1	S-25305	Balance-Semi-micro mettler H-18 for 110 to 220 V 50/60 cycles	970.00	970.00
1	S-2536-12	Extra Bulb for above	2.50	2.50
1	S-20793	Colorimeter, Regulated Model B&L Spectronic 20 Tropical package, for 220, 240 and 115 V 50/60 cycles *	495.00	495.00
6		Extra bulbs for above	2.50	15.00
1	S-43615-A	Incubator, electric Blue M 115 V 50 cycles	169.00	169.00
1	S-30960	Transformer for above for 240 V.	17.80	17.80
1	S-76491	Stirring apparatus-magnetic 50/60 cycles *	38.50	38.50
2	S-76494-A	Stirring bars	2.00	4.00
2	S-76494-B	Stirring bars	2.00	4.00
2	S-76494-C	Stirring bars	2.00	4.00
1	S-30008	Ph Meter portable Sargent Model PL with switch to permit operation from either 115 or 250 volt, 50/60 cycles A.C. *	305.00	305.00

* Automatic voltage regulator may be required. See manufacturer's recommendations.

Supplier: Sargent-Welsh Scientific Company (Continued)

1	30008-15	p H Meter power supply Battery operated for use with S 30008 to permit battery operation	25.00	25.00
2	S-30960	Autotransformer 230 to 115 volts	17.80	35.60
1 case of 2	S-31265-C	Extraction assemblies Soxhlet, consisting of S-31385 extractor and S-34225 flask	79.82/2	79.82
2	S-40866-H	Heating mantles-Electric for flask capacity 1000 ml	17.50	35.00
2	S-40868-H	Heating mantle supports	6.00	12.00
2 lb	S-73305-A	Rubber stoppers, size 00	2.15 lb	4.30
2 lb	S-73305-C	Rubber stoppers, size No. 1	2.15 lb	4.30
2 lb	S-73305-D	Rubber stoppers, size No. 2	2.15 lb	4.30
2 lb	S-73305-G	Rubber stoppers, size No. 5	2.15 lb	4.30
2 lb	S-73305-10	Rubber stoppers, assortment	2.15 lb	4.30
6	S-78305-D	Supports, steel, large base	6.75	40.50
5	S-78710	Support test tube, rubber plated steel, 40 place	5.00	25.00
1	S-78536	Support, burette, double porcelain base	12.00	12.00
2	S-19035	Clamps, burette, double	3.50	7.00
6	S-80005-C	Thermometer, centigrade - 20 to 150	2.60	15.60
1 case of 2	S-10925-C	Burette, Micro-class A5 ml	53.74/2	53.74
	S-24640-B	Cylinders, graduated, polypropylene 10 ml	1.90	5.70

Supplier: Sargent-Welsh Scientific Company (Continued)

4	S-24665-D	Cylinders, graduate pyrez 50 ml	4.10	16.40
4	S-24665-E	Cylinders, graduate pyrex 100 ml	4.77	19.08
1	S-24640-H	Cylinders, graduate polypropylene 500 ml	4.90	4.90
1	S-19705	Clock, interval timer, 120 minutes	12.95	12.95
7 cases of 18	S-34405-B	Flasks, Kjeldahl, long neck pyrex 30 ml.	25.20/18	176.40
3	S-34865-F	Flasks, volumetric, stopper Class A ml cap.	3.41	10.23
3	S-34865-G	Flask, volumetric, stopper Class A	3.63	10.89
3	S-34867-L	Flask, volumetric, stopper Class A	6.05	18.15
1 case of 18	S-69506-A	Pipettes, volumetric Class A1 ml	28.80/18	28.80
3	S-69506-B	Pipettes, volumetric Class A2 ml	1.65	4.95
7	S-69506-C	Pipettes, volumetric Class A3 ml	1.65	11.55
7	S-69506-E	Pipettes, volumetric Class A5 ml	1.65	11.55
1 dozen	S-69625-C	Pipettes, serological, graduated downward 1 ml	13.50/12	13.50
1 dozen	S-69625-G	Pipettes, serological graduated 5 ml	13.50/12	13.50
2	S-69765-A	Pipettes, duplicating, safety 2 ml	6.75	13.50
2	S-69765-B	Pipettes, duplicating, safety 5 ml	7.25	14.50
3	S-69771-A	Pipette tubes-graduated, 2 ml	1.36	4.08
3	S-69771-B	Pippete tubes-graduated, 5 ml	1.50	4.50

Supplier: <u>Sargent-Welsh Scientific Company (Continued)</u>

1 dozen	S-69772-A	Bulbs, for pipette 2 ml	.24	2.88
1 dozen	S-69772-B	Bulbs, for pipette 5 ml	.30	3.60
200	S-79525-D	Test tubes, bacteriological 100 x 13 mm	.04	8.00
200	S-79525-K	Test tubes, bacteriological 150 x 19	.06	12.00
5 cases of 288	S-83246-F	Vials, short style, screw cap, cap. size 18-400	49.82/288	249.10
2 cases of 288	S-83246-H	Vials, short style, screw cap, cap size 20-400	54.00/288	108.00
10 dozen	S-20810-A	Colorimeter-test tube 1/2 inch	8.50/12	85.00
6	SC-10255-5 lb	Acetic acid, glacial, reagent A.C.S.	7.15	85.80
6	SC-10268-1 pt	Acetone	2.85	17.10
2	SC-11096-5 lb Merck	Boric acid, U.S.P. powder	6.50	13.00
2	SC-11582-1 lb	Cupric sulfate, fine crystal	2.50	5.00
1	BK-1792	Cupric Chloride, reagent crystal	7.12	7.12
2	BK-9309-5 Gl	Hexane	42.00	84.00
2	5 Gl.	Ethanol 95% (Is available in Kenya)	10.00	20.00
2	BK-1996-1 lb	Ferric Chloride	3.22	6.44
4	9 lb	Hydrochloric acid (Is available in Kenya)	6.84	27.36
2	BK-2620-1 lb	Mercuric Oxide, red	35.71	71.42
1	SC-13585-4 oz	Methyl Orange, reagent	1.30	1.30
2	SC-13604-4 oz	Methyl Red, reagent	3.50	7.00

Supplier: Sergent-Welch Scientific Company

1	BD-9069-1 pt	Methyl alcohol	2.63	2.63
1	BK-2870-1/4 lb	Phenolphtalein, reagent	3.17	3.17
1	BK-2958-1 lb	Potassium biphthalate, reagent crystal	7.00	7.00
1	BK-3094-5 lb	Potassium dichromate, tech.	8.40	8.40
1	BK-3282-5 lb	Potassium sulfate, reagent powder	11.50	11.50
2	BK-3460-5 lb	Sodium acetate, reagent crystal	11.15	22.30
1	BK-3004-1 lb	Sodium carbonate, reagent	1.84	1.84
2	BK-3722-5 lb	Sodium hydroxide, reagent pellet	8.95	17.90
5	BK-3954-1 lb	Sodium Thiosulfate, reagent anyhdrous	2.50	12.50
1	BK-3568-5 lb	Sodium borate, crystal, A.C.S.	8.20	8.20
4	BK-9681-9 lb	Sulfuric acid, reagent	6.84	27.36
1	BK-3506-5 lb	Sodium Bicarbonate, reagent A.C.S.	6.50	6.50
1	BK-3822-1 lb	Sodium Phosphate, dibasic reagent A.C.S.	4.10	4.10
1	BK-3246-1 lb	Potassium phosphate, monabasic reagent crystal, A.C.S.	3.00	3.00
				4197.91
				=======
				3733.21

Supplier: Curtin Scientific Company

Address: P.O. Box 1546, Houston, Texas 77001 - USA

Quantity	Catalogue Number	Description	Unit Price	Total Price US $
3		Digestion apparatus, Micro Kjeldahl Labconco 60300-01, volts *	230.00	690.00
1	09-95200	Centrifugue, size 2 model K international for 50/60 cycles 240 volts *	1,360.00	1,360.00
1	049-486	Centrifugue head, horizontal, 8 place for use with model K size 2	83.00	83.00
8	050-427	Trunion Carrier, 8 place with rubber cushions	19.50	156.00
8	050-195	Metal shields 2/rubber cushion	6.50	52.00
1 dozen	050-872	Rubber cushions	1.35	1.35
8	050-310	Trunion rings	5.00	40.00
1 pkg. of 12	030-974	Brush, test tube	3.84/12	3.84
1 pkg. of 12	039-602	Brush Cylindrical	13.20/12	13.20
1 pkg. of 12	040-113	Brush Cylinder	4.92	4.92
2 pkg. of 144	079-053	Dish, weighing aluminium foil, 67 mm diam	3.00/144	6.00
5	079-657	Scalpel handles, size 3	3.15	15.75
2 pkg. of 12	079-699	Scalpel blades, size 11	2.15	4.30
5	262-618	Forceps, dissecting	.58	2.90
2 cases of 48	097-170	Flask, Erlenmeyer, narros mouth 125 ml	24.96/48	49.92

* Automatic voltage regulator may be required. See manufacturer's recommendations

Supplier: Curtin Scientific Company

6	097-212	Flask Erlenmeyer, narrow mouth 500 ml	.77	4.62
1 pkg.	038-620	Bottles, washing, polyethylene 500 ml. capacity	9.24	9.24
1	215-434	Super-Mixer labline	70.00	70.00
			TOTAL	2,567.04

Supplier: Sears Roebuck and Company (Or Equivalent)

Address: 4640 Roosevelt Blvd., Philadelphia, Pa. - USA

Quantity	Catalogue Number	Description	Unit Price	Total Price US $
1	46668630 N	Top freezer refrigerator 16 cubic ft. (50 cycles) 240 volts	264.95	264.95
1	4668050	Icemaker Kit	40.00	40.00
1	35 Spec.	1000 watt transformer for above refrigerators to operate on 240 volts *	29.25	29.25
				334.20

* Not needed if 240 volt, 50 cycle refrigerator is available

Supplier: Nutritional Biochemicals Corporation

Address: 26201 Miles Avenue, Cleveland, Ohio, 44128 - USA

Quantity	Description	Unit Price	Total Price US $
2 x 1 g	Brom Cresol green	2.50	2.00
2 x 1 kit	Kit 22 aminoacids	11.50	23.00
4 x 500 g	Papain, Tech, powder	15.50	62.00
4 x 10 g	DL-Tryptophan	2.58	7.74
2 x 100 g	L-Lysine monohydrochloride	2.85	5.70
2 x 10 g	2-Chloro 3, 5-cinitropyridine	27.50	55.00
			288.46
			======
			155.44

Supplier: A. [illegible] Thomas, Company

Address: Vine Street at Third, P. O. Box 779, Philadelphia, Pa., 19105 - USA

Quantity	Catalogue Number	Description	Unit Price	Total Price US $
3	7497	Kjeldahl distilling apparatus micro, one piece model 115 volts 50/60 cycle	290.00	870.00
1	9708-H2	Autotransformer, variable step-down for 120 volts apparatus on 240 volts line, 50 cycles	42.00	42.00
4	8988-F10	Spatula, Lab-Scoop	1.20	6.00
4	9006-M2	Handle wood, 5 inches long	.57	2.28
				920.28

Supplier: Crescent Dental Manufacturing Company

Address: 7750 W. 47th Street Lyons, Illinois, 68534 - USA

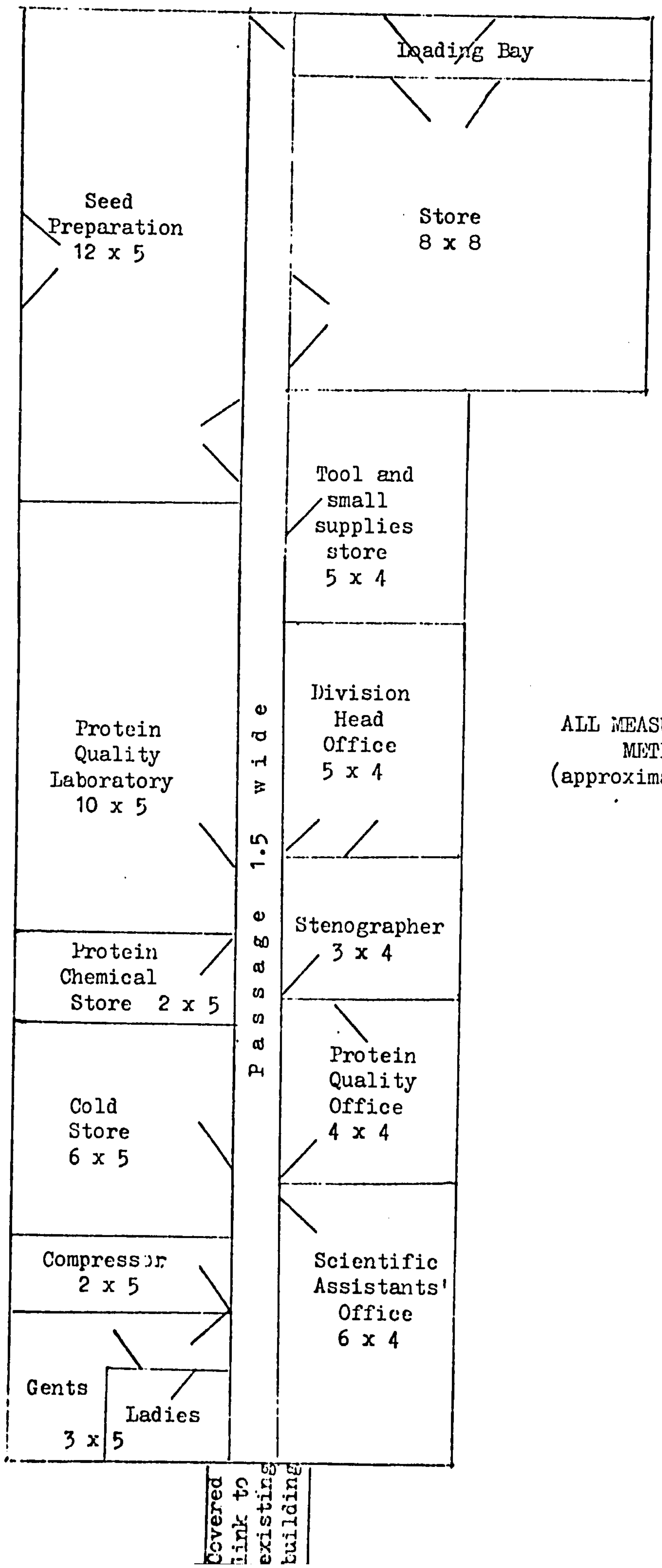
Quantity	Catalogue Number	Description	Unit Price	Total Price US $
2	31103 A	Wig-L-Bug Amalgamator 240 volts 50/60 cycles with 3113 vial adapter	96.50	193.00
2	3114	Vial, stainless steel 1/2" x 1" long	8.00	16.00
				209.00
Grand Total				8,016.89
10% allowance for inflation				801.69
				8,818.58

Supplier: GSA

Quantity	Catalogue Number	Description	Unit Price	Total Price US $
1	7110-262-6673	Base, bookcase section	5.00	5.00
2	7110-262-6648	Bookcase, section	15.20	30.40
2	7110-262-6650	Bookcase, section	19.00	38.00
1	7110-273-8774	Cabinet, card filing	5.30	5.30
2	7110-551-5486	Cabinet, file, legal, 5 drawer	81.00	182.00
2	7125-285-1803	Cabinet, small parts	34.50	69.00
3	7125-641-5436	Cabinet, storage	34.00	102.00
	Canon L163 or equivalent	Calculator, electronic	400.00 est.	400.00
1	7110-262-6690	Chair, office	49.50	49.50
1	7110-270-9840	Desk, steel, double pedestal	75.00	75.00
1	7110-143-9131	Desk, typewriter	83.00	83.00
	local	minor office supplies	100.00 est.	100.00
4	7110-634-9618	Stool, steel	10.40	41.60
1	7110-626-6663	Table, steel	38.00	38.00
1	7110-262-6681	Top, bookcase section	3.85	3.85
Grand Total				1,223.15
10% allowance for inflation				122.31
				1,345.46

SKETCH OF GROUND FLOOR PLAN FOR NEW OFFICE/LABORATORY EAAFRO KITALE SUBSTATION

Parking lot



ALL MEASUREMENTS IN METERS (approximate figures)

STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT A2 - DISEASE RESISTANCE IN MAIZE

I. BACKGROUND

A. PAST

Among the various diseases of maize at the lower and middle elevations of East Africa, the Maize Streak Virus (MSV) disease has been the most serious for many years, Dr. H. H. Storey, while serving as virologist at the Amani Station in N. E. Tanzania, described the disease in 1925, and in subsequent years worked out the details of the virus transmission by leaf hoppers. Sugarcane and a number of grasses are also susceptible, but virus isolates show considerable host specificity. Prevalence of the disease in the field is dependent on the presence of the virus in various host plants and on the frequency with which the insect vector occurs. Plants which are infected early are severely stunted and will produce no grain - with later infection yield reduction is less severe. Although the severity of the dieases varies from season to season, in aggregate the disease can cause large losses in maize. EAAFRO virologists are presently testing the effects of Streak on yield, but are estimating losses of 50% when the disease is severe under natural infection.

Streak disease is not a problem during the normal growing season at the higher elevations where most of the commercial maize is grown, but has a much greater impact on the small scale subsistence farmers at altitudes below 5,000 feet. In addition to yield losses, streak also severely limits the time of planting as the disease is much more severe in late or off-season plantings.

In contrast to what has happened with southern maize rust (caused by Puccinia polysora) across Africa, no substantial resistance to streak appears to have evolved in indigenous maize even though the disease has been prevalent for many years. This would suggest that selecting or roguing for resistance, at least in indigenous maize, is not likely to be fruitful. Exotic populations may offer more opportunity, but introducing known sources as a starting point would be more direct.

Gorter, in South Africa, found some sources of tolerance to Streak; but the resulting resistanc hybrids had no yield advantage even when the disease was present. Storey worked with essentially the same tolerance and found that it was inherited as a recessive - because of this and perhaps the earlier yield results, the tolerance source has never been used, to our knowledge, in any commerical variety.

It has been reported that some work was done in the past at the Ilonga station in Tanzania in selecting for resistance to Streak and other diseases in their populations, but to the best of our knowledge this has not been carried forward. The present breeding program there does involve the roguing of plants obviously infected with Streak.

Sugarcane Mosaic Virus (SCMV), which also infects maize, has been shown to be wide spread in East Africa. While losses due to this disease are less severe than those of Streak, yield reductions of up to 25% have been demonstrated in yield trials with artificial inoculation. A severe natural incidence could reduce yields by a similar amount. The loss in maize from SCMV in 1970-71 was estimated as one million bags in Kenya. The virus is naturally transmitted by aphids, and in contrast to streak, it can be artificially transmitted by plant sap inoculation.

Other diseases of maize also occur at the lower elevations, i.e., Southern Maize Rust (P. polysora), South Maize Leaf Blight (Helminthosporium maydis) and minor virus diseases, i.e,, Maize Stripe and Maize Line Viruses. Others, such as Downy Mildew (Schlerospora spp.), are not known to be present, but could be a problem if accidently introduced from countries east of 60^{o} longitude and some other areas. A disease resistance breeding program in the lower elevations would have to take these diseases into account. The set of diseases is distinctly different from those of the higher elevations where Puccinia sorghi is the major rust organism and Helminthosporium turcicum gives the more common leaf blight.

B. PRESENT SITUATION

1. Success to Date

The sources of resistance to Streak identified by Gorter and by Storey apparently have not been useful in breeding programs. Now, however, several sources of resistance have been confirmed at EAAFRO by Bock and Guthrie using leaf hopper transmitsion in the green house. These sources include Michoacan 21 X Stiff Stalk Synthetic, Mexico 55, Yucatan 16, Guatamala 252, TZB-Sr, and Reunion Revolution 198. Increased seed from sib pollinations among resistant plants is being made available to interested breeders and can serve as the basis for an accelerated Maize Streak breeding program. Other sources of resistance are likely to be found as work progresses. Immunity or high resistance may not be necessary, or even desirable, if tolerance enables plants to develop normally in spite of infection and some symptom development.

At present there is no maize breeding program making a concerted effort to introduce the resistances mentioned above into low and medium elevation improved populations. (See Appendix B-1 for Plant Pathology - Nematology Division, EAAFRO, situation.)

2. Constraints

a) The MSV cannot be transmitted mechanically and with controlled leaf hopper transmission only very small numbers of plants can be tested for resistance. Natural infection in maize populations grown in the field during the regular season tends to be unreliable - thus screening for resistance is difficult. However, experience had indicated that more consistent infection of susceptible plants may be obtained in irrigated crops during the dry season as the insects move from nearby grasses as they mature and dry out.

b) It is not always possible to determine Streak on the basis of symptoms, but an antiserum has been produced by Bock and Guthrie, workers at Muguga, which permits positive identification. Obviously this enhances the possibilities for an effective breeding program.

c) Natural selection in indigenous maize populations apparently has not resulted in the build up of improved resistance to Streak. Thus other techniques must be used. We believe that the incorporation of known sources of good resistance, followed by modern selection methods, should be successful in developing resistant, adapted populations, and eventually varieties in cooperation with national breeding.

d) Limited tests of East African maize varieties and hybrids with local Sugar Cane Mosic Virus strains have not located resistance. However, resistance to U.S. stains of the virus has been found in U.S. hybrids.

e) There is no breeding station dedicated to breeding for disease resistance in low altitude maize. One must be developed. Kibaha, Ilonga and Morogorow (all in Tanzania) have been suggested as sites.

3. Location of Maize Resistance Project

In breeding for resistance it is desirable to locate the program where the disease (or diseases) is likely to occur regularly with reasonable severity. Each of the three suggested sites in Tanzania appear to fulfill this requirement.

The Ilonga station would have the advantage of close proximity and the possibility of better cooperation and interchange with the Tanzanian - IITA maize program there. However, housing for staff and office-laboratory facilities are not available there. Location at Morogoro would have the advantage of cooperation with the staff of the Faculty of Agriculture of the University of Dar-es-Salaam, but again physical facilities are not available.

The Kibaha location has the primary advantage in that it is already designated substation of EAAFRO and the EAAFRO sugarcane breeding program is located there. It is our understanding that housing and office-laboratory space would be available there. Contact between Kibaha and EAAFRO at Muguga and Kitale will also be somewhat easier than with either Ilonga or Morogoro.

Land for nurseries and field plots at Kibaha would have to be away from the station itself, because of the rule against the growing of maize on the station due to the possible bringing in of virus diseases detrimental to sugarcane. This would be somewhat of a disadvantage, but not insurmountable. Another possible problem is the need for irrigation so that off-season nurseries, more favorable for streak development, can be grown satisfactorily. Considering all factors, Kibaha seems to be the most logical location. There appears to be no good choice other than the Kibaha location, in spite of the problems that will have to be worked out.

4. Other Agencies and Donors Involved

a) British ODA, Drs. K. R. Bock and E. J. Guthrie, virologists located Muguga, have expressed the need for work in this field and have indicated a willingness to cooperate with the pathologist and breeder working on this subproject. As indicated earlier, they have resistance sources available. They would also be of great assistance by helping identify strains of the MSV that might develop as the work progresses.

b) The Partner States have stressed the need for disease resistance breeding for the lowland areas and have indicated their willingness to cooperate.

5. Relationships Between EAAFRO and National Research

a) Maize varieties with resistance to MSV and other diseases, improved protein quality, and improved agronomic traits are a common need of all the Partner States. It is of utmost importance that selection for all these characteristics be integrated tino a single breeding program. EAAFRO can incorporate disease resistance into otherwise improved populations which can be used by national breeders. The final stages of the selection and the release of varieties will be the work of the national breeders of the Partner States.

6. EAAFRO's Capabilities, Direction and Viability

The Director of EAAFRO, Dr. Majisu, is capable of providing the necessary guidance from the administrative standpoint, especially since he has had experience as a sorghum breeder.

Close cooperation with the highly successful EAAFRO maize breeding methodology study at Kitale will strengthen this subproject, especially if the experienced technician can have some input in getting the new subproject under way and advising as to most efficient breeding systems to use. The protein quality laboratory will also be of value for this project, as hard endosperm opaque-2 will be one of the characters of interest.

As indicated previosuly, the EAAFRO virologists will be important as sources of information on the viruses and for strains which come into play as the program progresses, for providing possible sources of resistance, and advise on ways of developing the best possible disease epidemics required for effective selection.

EAAFRO has been requested by the Partner States to undertake this disease resistance program, and is to take the next essential steps of incorporating this resistance with other desirable traits, such a adaptation, plant type and high quality protein, in populations which finally can be developed into synthetic varieties suitable for low to medium elevation maize areas by the national breeders.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1. Objectives

a) To establish EAAFRO research in the low land maize area where Streak and other diseases are severe.

b) Incorporate resistance to MSV into adapted low altitude composites (five such composites are now available) to form broad based populations. Resistant material already identified by EAAFRO will be a starting point, others undoubtedly will be found.

c) Determine inheritance of Streak resistance. Knowledge of the mode of inheritance is essential in determining the type breeding program to be carried out.

d) As a second priority search for and when available begin to incorporate resistance to SCMV, H. Maydis, P. polysora and to other diseases that become economically important.

e) Begin simulataneous incorporation of opaque-2 and subsequent selection for vitreous endospern in the disease resistant populations.

2. Relationship to Other Subprojects

a) Close cooperation with the highly successful EAAFRO maize breeding methodology subproject will strengthen and support this project by supplying some of the initial breeding material, by advising on the most efficient breeding methods to accomplish objectives and by input from the experienced USAID technician in getting the new project under way.

b) The protein laboratory subproject will have a direct input as simultaneous selection for opaque-2 and vitreous endospern as well as disease resistance progresses. The laboratory would also be of assistance in the interpretation of results obtained on selections tested.

c) The plant pathologist-virologist on this subproject would be available for consultation on virus and other disease problems in the breeding methodology study, the sugarcane and the quarantine subprojects, although his first priority would remain with the disease resistance breeding program.

3. Technical Feasibility

a) With the indicated inputs, this subproject is feasible if it is conducted on a long-term basis, primarily because of the number of plant characters involved as well as the time required for counterpart training and experience.

b) Initial sources of resistance to Streak are available. With effective screening other sources should be found in introduced germ plasm.

c) With off-season nurseries under irrigation and the favorable environment in the Kibaha area effective screening for Streak, etc. will be possible.

d) Protein quality laboratory will make incorporation of opaque-2 with vitreous endosperm possible.

e) The willingness to cooperate indicated by national breeders will make testing of populations under diverse environment possible.

4. Beginning and End Points With Intermediate Targets for USAID Assistance (See Table 1)

a)	Identification of USAID technician breeder	- by December, 1975
	Posting of same to Kibaha	- by January, 1976
b)	Identification of USAID plant virologist	- by December, 1975
	Posting of same to Muguga	- by January, 1976
c)	Ordering and arrival of commodities	- by January, 1976
d)	Counterparts (4) Identification	- by December, 1975
	On-the-job training	- by January-December, 1976
	U. S. training to M. S.	- by 1977-78
	On-the-job training	- by 1979

5. Importance to the Development of Food Crops in East Africa

a) This subproject would lead to the removal of one of the main constraints, diseases such as Streak and Sugarcane Mosaic, on the production of maize at low and medium elevations through the development of resistant populations from which national breeders can develop varieties.

b) It will also lead eventually to improved quality protein for the rural and low income urban people, who are largely dependent on cereal protein, as the opaque-2 character is introduced.

c) It is believed that by supplying disease resistant, opaque-2 populations this subproject will enable national maize breeders to progress rapdily toward disease resistant varieties for low elevations.

B. EXPECTED OUTPUTS

1. Basic Assumptions Required for Success

a) That satisfactory sources of resistance to Streak (and other diseases) exist and that these can be stabilized effectively in breeding populations. This would also depend on the relative stability of the viruses, i.e. more highly virulent strains do not develop in the presence of resistant plants.

b) That reasonably severe disease epidemics can be induced so that screening is effective.

c) For this subproject to be most effective, good cooperation with Partner State breeders at lower elevations is needed.

d) That counterpart trainees can be promptly identified and successfully go through the several phases of training.

2. Predicted Impact at End of USAID Assistance

a) The establishment of a viable EAAFRO program of breeding maize adapted to lower elevations, particularly with respect to diseases.

b) Strengthening EAAFRO's leadership and contribution to the Partner States is maize research, particularly at lower elevations, to a point of being capable of handling a disease resistance breeding program with East African staff.

c) In four to five years populations with improved disease resistance and higher protein quality should be available to national breeders.

III. REQUIRED INPUTS

A. EAAFRO CONTRIBUTION

(See Table 2)

B. USAID CONTRIBUTION

(See Table 2)

IV. CONCLUSION AND RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

1. The development by EAAFRO of high quality disease resistant maize populations for use by national breeders in developing varieties for low and medium altitude areas should receive a high priority.

2. After consideration of several alternate sites, we conclude that the EAAFRO program should be headquartered at Kibaha, Tanzania, in close proximity to the Sugarcane Station so that office and laboratory space as well as machinery and other equipment could be shared. Regulations prohibit maize trials on the station proper, but not in the area. The climate is reasonably typical of a large part of Tanzania and Kenyan lowlands and is favorable for developing the high incidence of streak and other diseases, thus permitting effective selection procedures. The fact that the Kibaha station is EAAFRO property will facilitate locating the program in the area.

Since both maize and sugarcane are hosts for Streak and Sugarcane Mosaic, there should be considerable interchange for ideas between the sugarcane station personnel and the maize disease technicians. This gives credence to the location of maize disease work near the Kibaha station. There may be some concern that the diseases of maize will put undue stress on the sugarcane. However, it should be pointed out that there are currently smallholders' corn patches in the vicinity of the station, and thus the maize disease trials would not add anything that does not already exist. The maize unit can be located at a distance which is mutually agreeable. Breeding for resistance to Streak and other diseases, for high quality protein, for agronomic performance and possibly insect resistance should all be integrated into this program. EAAFRO's primary function in the resistance breeding program would be to establish and stabilize resistance in adapted populations for use in national maize breeders. Close coordination with the two subprojects located at Kitale and with the national maize programs of the Partner States is very important.

B. RECOMMENDATIONS

1. The team recommends that USAID support the establishment of an EAAFRO maize disease resistance program for the low and medium altitudes.

2. It is recommended that Kibaha, Tanzania, be the first choice for headquarters for program.

3. It is further recommended that in order to get the program started two USAID technicians be supplied. One should be a plant breeder with experience and, if possible, some background in plant pathology, to be located at Kibaha. The second would be a plant pathologist with considerable competence in virology to be located at EAAFRO headquarters at Muguga in association with the ODA virologists. His primary responsibility would be to the disease resistance program in working with the breeder in identifying diseases, developing controlled epicphytotics and making selections. He would also be available to consult inthe sugarcane breeding program at Kibaha, and to act as a backup for the Quarantine Station technician at Muguga.

TABLE 1

KIBAHA

	Responsibility	
	EAAFRO	AID
A. Physical facilities		
Obtaining control of land	X	
Clearing of land (10 acres first then additional 10 for rotation)	X	
Building of fences	X	
Building - Field Headquarters	X	
Well construction	X	
Instal pump and irrigation equipment		X
Vehicle - (pick-up truck)	X	
Office and laboratory equipment		X
Rent of Dar es Salaam housing for technicians (If with school age children)		X

	ACTIVITY	75	76	77	78	79
B.	Personnel					
	Identification of plant breeder U.S. Technician	→				
	Posting of same to Kibaha		→	→	→	→
	Identification of pathologist-virologist	→				
	Posting of same to Muguga		→	→	→	→
	Identification of counterparts and on-the-job training		→			
	Graduate study in U.S.			→	→	
	Post graduate on-the-job training					→

TABLE 2

TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR MAIZE DISEASE RESISTANCE SUBPROJECT

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Personnel										
(1) USAID technician (plant breeder)	50,000	50,000	50,000	50,000	200,000			X		
(1) USAID technician (pathologist-virologist)	50,000	50,000	50,000	50,000	200,000			X		
(2) Research Officer Trainees (breeder counterpart)	6,200			5,000		11,200	X			
(2) Research Officer Trainees (pathologist counterpart)	6,200			5,000		11,200	X			
(1) Scientific Assistant	2,400	2,400	2,400	2,400		9,600	X			
(1) Laboratory Assistant	1,100	1,100	1,100	1,100		4,400	X			
(1) Steno Clerk	1,500	1,500	1,500	1,500		6,000	X			
(3) Field Staff	1,800	1,800	1,800	1,800		7,200	X			
Participant Training										
(4) Research officer for advanced training	41,400	36,000	18,000		95,400			X		
Commodities										
(1) Land Rover	7,900				7,900			X		
Irrigation well										
- Bore hole	2,000					2,000	X			
- Pump and motor	2,500				2,500			X		
- Irrigation equipment	3,000				3,000					
Farm supplies	500	500	500	500		2,000	X			
(2) Microscopes	1,500				1,500			X		
(1) Pressure cooker	50				50			X		
(1) Typewriter	500				500			X		
(1) Thermofax	250				250			X		
Office Equipment	1,000				1,000			X		

Table 2

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
	$	$	$	$						
Land and Structure										
5 Acres	500	500	500	500		2,000			X	
Land Clearing	500					500	X			
Storage Shed	5,000				5,000			✓		
Travel and Per Diem										
Outside East Africa	5,700	5,700	5,700	5,700		22,800	X			
Within East Africa	2,285	2,285	2,285	2,285		9,140	X			
Consumbale Supplies and Utilities	4,000	4,000	4,000	4,000		16,000	X			
TOTAL FOR PROJECT					517,100	104,040				

JOB DESCRIPTION FOR USAID PLANT PATHOLOGIST

FOR DISEASE RESISTANCE IN MAIZE SUBPROJECT

Training: Ph.D. or M.S. with considerable experience in plant pathology-virology.

Experience: At least three years experience in research and field work on virus diseases of crop plants. Some experience with maize would be desirable.

Duties: Monitor diseases of maize, particularly viruses, in low and medium altitudes of Partner States. Work with low elevation maize breeder, USAID technician, in developing conditions favorable for disease development, Streak initially, and selecting for resistance or tolerance. Verify field resistance in controlled greenhouse tests with viruliferous leaf hoppers. Conduct search for other possible sources of resistance to important diseases. Serve as consultant on disease problems for EAAFRO sugarcane breeding program and for maize breeding methodology/high quality protein program. Advise with Quarantine Division Head on problems of mutual concern.

Note: Candidates for this position should consult Plant Pathology situation statement (Appendix B).

JOB DESCRIPTION FOR USAID PLANT BREEDER

FOR DISEASE RESISTANCE IN MAIZE PROJECT

Training: Ph.D. or M.S. with considerable experience in plant breeding, with some background in plant pathology.

Experience: At least five years experience in plant breeding. Some experience with maize or other cross pollinated crop would be highly desirable.

Duties: Initiate breeding program for resistance to Streak (MSV) and other diseases in maize populations adapted to low to medium altitude conditions. Introduce known sources of resistance to Streak into the best currently available populations, and by the most efficient recurrent selection methods available, build up the field resistance of the populations. To the degree possible, simultaneously introduce opaque-2 and improve the protein quality of the populations. Breeding methods would be chosen on the basis of the Kitale Methodology study findings and in cooperation with USAID Geneticist at Kitale. Protein quality testing would be done at the protein laboratory to be located at Kitale. Technician would have assistance of virologist, USAID technician, located at Muguga on disease aspects. Populations with improved disease resistance and protein quality would be supplied to national breeders for final selection and release.

PLANT PATHOLOGY SITUATION STATEMENT

PLANT PATHOLOGY - EAAFRO - FEBRUARY, 1975

Plant Pathologist-Virologist

There are two English virologists working with EAAFRO at Muguga, Drs. K. Bock and E. J. Guthrie. The EAAFRO Division of Plant Pathology-Nematology is presently very short of trained personnel. The Acting Head, Dr. Ngundo, is a young nematologist who worked for about two years with an USAID technician on important nematode problems on beans, rice and bananas. In addition, thre are three virologist posts, with no one aboard at present. For one of these posts there is a trainee studying for the M.S. degree at Maryland, but his shift to the Quarantine Station plant pathologist position has been suggested. With this lack of trained people, the presence of an USAID technician-virologist to work with the maize disease resistance project, but to be located at Muguga, would greatly strengthen the position of EAAFRO while additional people are being trained. Since 1973 they have been supported entirely by British ODA with their commitments being on the viruses and virus diseases of maize and legumes. They apparently have no EAAFRO input except physical facilities, i.e., office, laboratories, glass-houses, nursery plots and residences. They have ultrascentrifgue, spectrophotometers, etc. - all the instruments needed for basic virology research.

Their work involves the critical identification of viruses. For example, in Maize Streak Virus (MSV) they have purified it, characterized it morphologically (by electron microscopy in England) and serologically and prepared antiserum as an aid in identifying the virus in field collections. They have checked isolates for occurrence of different pathologic strains. They have imported maize germ-plasm and have been screening these for field resistance to MSV. They have also been searching for resistance to the maize strain of Sugarcane Mosaic Virus. In Maize, MSV and SCMV are the two that they have commitments to primarily, although the Stripe and Line Viruses are being watched.

Their premise is that if they can make positive identification of a virus that occurs in East Africa, and the virus is well known in other parts of the world, then they may be able to obtain resistant germplasm from the places where the virus has been studied previously. Thus they would avoid random searches of germ-plasm collections.

With MSV they have found the virus to be remarkably stable. The strain that Storey worked with is still available and its pathological behavior is the same as more recent isolates. They have also found plants with various degrees of resistance or tolerance from several sources as listed in the report on the Disease Resistance subproject. Individual plants are tested by moving viruliferous leaf hoppers alternately from a known susceptible plant to a test plant and then to another suceptible plant. If the known susceptible plants come down with virus, but the test plants show little or no effects, then they are sure that the plants do have some resistance. These plants are allowed to flower and then sibbed within sources and selfed the next generation and also crossed with susceptible plants to begin a determination of inheritance, so that eventually use in breeding program can be more efficient.

STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT A3 - CONTINUATION & TRANSITION OF MAIZE BREEDING METHODOLOGY RESEARCH

I. BACKGROUND

A. PAST

The breeding methods study was initiated in 1964 to compare several different methods of recurrent selection under East African conditions using local and introduced populations of maize (*Zea mays* L). The project was designed to assist national maize research programs in East Africa in the selection of breeding methods best suited for their own seasonal patterns, available resources, desired rate of improvement, and ultimate commercial use of the improved populations in each national maize breeding programs. Comparisons of methods included ear-to-row selection with several variations, mass selection, half-sib selection (recombining remnant selfed seed), S_1 line selection, full-sib selection, and reciprocal recurrent selection. Different germplasm materials, testers, plant populations, and selection intensities within a given breeding method were additional variables examined in the study. Materials used were Kitale II (KII), Ecuador 573 (Ec573) and Kitale Composite A (KCA) derived from the advanced generation of the KII X Ec573 cross. The names suggest the origin of the initial germplasm.

Ten years of the breeding methods study have been completed. However, because certain crop generations were delayed, some of the original studies have not been completed and because some comparisons were started at a later date evaluation was not completed in the 10 year period. A two year evaluation to clearly establish the effectiveness of the various methods is highly desirable to meet the goals of the original experiment. If evaluation is incomplete, the work that has gone into the experiment is compromised. Evaluation will not require full time effort and as the work load from these studies decreases, work on protein improvement can be initiated.

B. PRESENT SITUATION

1. Success to Date

The study successfully utilized the concept of population improvement in contrast to traditional inbreeding and line evaluation. As evidence of this success breeding programs of at least 7 African countries have formed composite breeding populations and are improving them by methods recommended by the EAAFRO breeding methods study. Breeders in National Programs were informed of the results in regional workshops for cereal researchers organized and held on a bi-annual basis. Such workshops are now held under the direction of the participating corn breeders from various African countires. The Kenya breeding program shifted in 1973 from S_1 to reciprocal recurrent selection on the basis of the results obtained to that date of the EAAFRO study.

A direct contribution of the maize breeding methods study to the agriculture of East Africa is the use of Ec573 (R12)C2, an improved population, as the male parent in 76 percent of the hybrid seed sold in Kenya. Further, Ec573 (R12)C2 and Kitale II (R11)C2 are the parental lines of Tanzania's highland commercial hybrid 611C. The same populations are being directly utilized commercially in Ethiopia.

The present status of the experimental work is summarized below. The selection phase of 14 of the original 17 experiments has been completed. The remaining three will terminate as follows:

a) 8 FL will finish the 5th cycle in July, 1977 (Forming a low yield population)
b) HI 16 will finish the 5th cycle in July, 1977 (Low yielding inbred tester)
c) F 18 will finish the 5th cycle in July, 1976 (full-sib selection).

Other experiments not completed because they were initiated later than the above but which should be continued with the possible earliest evaluation date are as follows:

a) Mass selection in KCA at a low plant population density (M17, cycle 10, 1978)
b) S_1 selection in Kitale II and Ec573 (S21, cycle 10, 1981 and S22, cycle 10, 1980)
c) Reciprocal recurrent selection with an inbred tester in Kitale II and Ec573 (RI23, cycle 10, 1984 and RI24, cycle 10, 1984)

The evaluation trials envisioned for the original 17 experiments and earliest possible evaluation dates are:

a) Ear-to-row and reciprocal recurrent selection in Kitale II and Ec573 in 1976 and 1977 (plus 1978 is possible) at 7 to 9 locations.
b) Ear-to-row and mass selection in KCA in 1976 and 1977 (plus 1978 if possible) at 7 to 9 locations.
c) S_1 half-sib with parent population, low yielding population, and low yielding inbred line as testers; and full-sib selection. Three of these populations are expected to be available in 1976, and the other two in 1978.

The breeding methods evaluation study was originally a projected 10 year study. The present team study is of USAID participation in a two year extension to that project. From the above analysis it can be seen that some populations will not be ready until 1977 and others only after the termination date of the proposed extension. The reason for this increased span of time is related to time in producing generations of maize rather than volume of work. During the two year extension the time spent by the breeder on evaluation of the experiment will decrease as the number and extent of the trials decreases. During the time it is suggested that a major effort be made to design ways and solicit cooperative arrangements of time and facilities to ensure that evaluation will be completed after the termination of the project.

The following priorities are recommended in allocating time of the maize geneticist:

1. Evaluation of the 10 year experiments on selection methodology.
2. Make provision to complete evaluation of the final three of seventeen experiments that cannot be completed within two years of the project.
3. Introduce opaque-2 germ plasm into EAAFRO breeding populations.

2. Constraints

a) Farm operation, management,and land preparation on the Research Station were constraints on the project which were solved by EAAFRO's acquiring the necessary equipment, i.e. a tractor, a plow, a disc harrow, cultivators and a sprayer. A corn planter is still needed.

b) Staff for the first 8 years were seconded to the project from the Kenya Government (GOK); presently EAAFRO has hired 18 staff persons and an additional 2 remain seconded from GOK.

c) A Scientific Assistant post was established by EAAFRO in 1972, but no recuit has been obtained. A Technical Assistant now carries most of the work load that would normally be the responsibility of a Scientific Assistant.

d) Laboratory-office space and housing for the USAID Technician have been rented from the GOK at Kitale, but now funds have been approved by EAAFRO for an office-laboratory building, two senior, two intermediate and 20 junior staff houses, and the agreement with the GOK to build on the National Agricultural Research Station was finalized in 1974. Building plans have been completed by the EAC architect. (See sketch of floor plan attached - Appendix A).

e) A counterpart to the USAID technician is not at post but has been appointed.

3. Other Agencies and Donors Involved

The following agencies have expressed interest in the maize breeding program, and several have been actively involved in testing material coming from the program:

a) International agencies

CIMMYT-Mexico - FAO-Egypt have participated in East Africa Maize Variety trials (EAMVT).

b) National agencies

1. The Kenya Ministry of Agriculture has cooperated in the establishment of the EAAFRO substation at Kitale and in sharing resources, e.g. offices, laboratories, land for experimental plantings.

2. The Kenya Seed Co., a parastatal corporation that produces and sells seed of maize varieties and hybrids, cooperates in EAMVT and contributes to the program.

3. British ODA has been supporting a maize agronomy project in conjuction with the Kenyan national program at Kitale.

4. The Tanzanian Ministry of Agriculture - testing will be centered at the Ilonga Agricultural Research and Training Institute, Kilosa.

5. The Uganda Ministry of Agriculture - a number of EAMVT trials are carried out in Uganda.

c) Other Agencies

Officers of research agencies of 11 other countries, in and outside of Africa have grown the EAMVT. The USDA has been involved by supplying technicians and consultants.

4 & 5. Relationships Between EAAFRO and National Research Programs

EAAFRO has the responsibility for phases that are generally applicable to the Partner States and would be duplicative if done by the Partner States separately. The breeding methods study has particularly been an EAAFRO function, but the improvement of maize populations in protein quality, disease resistance and other important characters is also an EAAFRO function. The national maize breeding programs have responsibility for final selection and release as varieties. Commercial utilization of populations from the breeding methods study has occurred.

6. Previous Studies on the Area of Work

In recent years, since it has become apparent that various recurrent selection schemes are more promising for long term maize improvement than the traditional inbreeding approach, many breeding methods studies have been conducted. However, most of these have been on a single method in a single population. Others have compared methods in pairs but the maize breeding methods study being conducted at Kitale under USAID and EAAFRO sponsorship is unique in its scope. Nowhere in the world has such a comprehensive study been made. Corn breeders all over the world, including those in the U.S. cornbelt, are keenly interested in the study and awaiting the fully evaluated results. The results of this method study could have application for other crops.

7. EAAFRO's Capabilities, Direction and Viability

The Director of EAAFRO, Dr. B. N. Majisu, is capable of providing the necessary guidance, especially since he was formally a sorghum breeder. The USAID technician, Dr. L. L. Darrah, is highly qualified, has made excellent progress, and has maintained good working relations with cooperators and with his staff. Such deficiencies in physical facilities as have existed are being corrected.

EAAFRO has an established worldwide reputation in the Breeding methods work. Their capacity to continue to produce and exert leadership seems unquestioned. Evidence of present leadership are the numberous requests from many countires for information and genetic materials. Regional variety trials, now in their sixth year, were established by EAAFRO. The trials are conducted in 11 African countries, in Mexico, Columbia and Nepal. This year (1975) seed for 89 trials in 14 countires has been distributed.

Regional workshops sponsored by EAAFRO and CIMMYT are now in the 5th year. The first three were held at the corn breeding station at Kitale, Kenya. During the 4th conference a steering committee of local breeders was elected so subsequent responsibility is in the hands of East Africans. An EAAFRO scientist is a member of this Committee. Thus EAAFRO leadership continues.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1 & 2. Objectives and Relationships to other Subprojects

a) To complete the breeding methods study, including evaluation and publication of results, so that it will make the maximum contribution to all existing maize breeding programs.

b) To continue to supply lines and populations with improved disease resistance and agronomic traits to the Partner States for use in the production of commercial varieties and hybrids.

c) To begin, as time permits, conversion of some improved populations to opaque-2 with hard endosperm in both high and low altitude maize. This will be in support of the Partner States maize breeding programs.

d) To assist in the establishment of the protein quality laboratory at Kitale as it is being set up and to guide and consult with the disease resistance breeding program for low altitudes as it is initiated at Kibaha.

e) To continue to assemble the high altitude regional variety trials and to cooperate in testing the low altitude regional variety trials assembled by OAU-JP-26 (as per agreement).

f) To provide young maize breeders from the Partner States with four to six month periods of training at Kitale.

3. Technical Feasibility of Subproject

a) EAAFRO with the USAID sponsored leadership has demonstrated a unique capability to effectively achieve the objectives of this project. Needed is an additional 2 year tour for the present USAID technician. The project is constantly monitored by a qualified USDA maize breeder who was previously in charge of the project.

b) Adequate land, irrigation facilities and trained field labor exists to permit proper operation of the project.

c) EAAFRO provides adequate office/laboratory space to permit efficient work.

d) EAAFRO also provides enough operating funds so that operations can run smoothly.

e) An excellent working relationship exists between Kenyan Ministry of Agriculture personnel and EAAFRO technicians so that each benefits from being physically together at Kitale.

f) There is a demand and utilization of project results in East Africa and in various other parts of the world that gives impetus for excellent achievement.

g) The most critical need is to adequately train the counterpart who has reportedly been appointed so that he can assume the project leadership before the current USAID project leader completes his present assignment.

h) Phasing in the hard endosperm, opaque-2 characters during the life of this project will require the services of an efficiently operating protein laboratory. USAID assistance as outlined in the protein laboratory subproject is most essential.

i) Currently computer work associated with the maize breeding project is done in Nairobi. This necessitates that the U.S. technician spends considerable time away from post to complete operations to implement work done by the large computer. Purchase of a small electronic computer for use at Kitale would greatly facilitate the project. (See description item C. under commodities category of Table 1).

j) Other commodity items as listed are needed to facilitate soil preparation, planting and storage operations. These items are to supplement those already provided by EAAFRO.

4. Beginning and Ending Point with Intermediate Targets for USAID Assistance

The subproject proposes continuation of an ongoing viable program for an additional two year period. Inputs should be made immediately to realize maximum benefits.

a) The P.A.S.A. agreement for the USDA - (USAID sponsored) maize geneticist should be continued for two years to permit him to return to post to continue his ongoing work.

b) Requested commodities should be purchased commensurate with subproject approval so that the USAID technician can work with a minimum loss of time upon return from home leave.

c) The appointed counterparts (one back-up can be used elsewhere if two are identified) should commence U.S. training not later than the Fall semester 1975. On-the-job training should begin as soon as the U.S. technician returns from home leave. This will permit familiarization with the breeding methods project prior to the commencement of formal Academic training. It is hoped that continuation of the phased-in opaque-2 program would permit exmployment of a U.S. technician for an additional period of time. This would make possible more adequate on-the-job training following completion of the academic coursework.

5. Importance of Subproject to the Development of Food Crops in East Africa

a) In the judgement of this team the methodology studies conducted by EAAFRO at the Kitale Station in Kenya are unique in the world. Not only do East African countries benefit in terms of improved maize varieties, but the methodology appears to be transferable to other regions and possibly to other crops. Prominent U.S. maize breeders have indicated that other breeders at several U.S. universities and CIMMYT are currently anticipating final evaluation of the methodology study which is the purpose of this subproject.

b) Congruent with development of the maize breeding methodology evaluation has been a remarkable development of high yielding maize hybrids adapted for a variety of environments in the temperate tropics.

c) The continued introduction of hybrids in the commercial market is expected to result in yield increases on the order of 4 to 6 percent per year.* The value of a single annual increment of this size in Kenya alone approaches $2,000,000 per year at current world market prices. When results of a similar but lesser magnitude elsewhere are added, a strong case for continuation and further evaluation by surrounding states is easily made.

d) Additional importance attaches to the methodology subproject when recognition is given to the extent to which it stands to compliment existing and contemplated programs in maize breeding. As the evaluation trials gradually are completed, the more efficient selection can be brought directly to bear on resistance to diseases, such as leaf blights, rusts, and streak, and on improved agronomic characteristics, such as yield, ear height, lodging and insect resistance. At the same time it creates an opportunity to introduce the opaque-2 character into the most advanced populations which in turn can be used by the national breeders for selection in their particular environment. Hybrids and improved composites developed as a result of these efforts should have a wider range of adaptability than those previously developed at Kitale, especially at lower elevations and in the coastal areas of East Africa.

* Estimates based on "Development Plan Kenya 1974-1978" and conversations with L. Darrah at the Kitale Station.

B. EXPECTED OUTPUTS

1. Basic Assumptions for the Success of the Project

a) That the cycles of selection can be completed and the evaluational trials carried forward.

b) That EAAFRO will complete the laboratory-office building it has already initiated. (Anticipated completion date: 1 July, 1976)

c) That counterparts can be recruited by EAAFRO and adequate training can be initiated within the time frame established.

d) That it is technically feasible to convert improved maize populations to high quality protein and acceptable kernel type. (Some hard endosperm opaque-2 lines now exist).

e) That the protein laboratory will be established that will permit phasing in high quality protein work.

2. Predicted Benchmarks of Achievement

a) By 1977, sixteen of the seventeen original maize breeding selection experiments will have been completed and the majority of them will have been evaluated.

b) By 1977, a major part of the breeding methodology study will be completed and pertinent manuscripts will have been prepared for publication.

c) By 1976, the hard endosperm opaque-2 character will have begun to be phased into EAAFRO maize populations.

d) By 1977, the 7th regional maize trial will have been completed and will provide additional information on the adaptability of the various maize lines.

e) By 1976, the EAAFRO maize breeding unit will be housed in their own office and laboratories.

f) By fall 1975, at least one East African trainee will have commenced training in a U.S. institution and by 1977 will have the necessary academic training to assume responsibility for the maize methodology program after receiving adequate on-the-job training.

g) By 1977, it will be possible to continue to provide leadership for the annual East African Cereals Workshops.

3. Predicted Impact

a) It is predicted that the best methodology available as identified by the project will be utilized by the African national maize breeding programs and by breeders around the world.

b) Maize populations with improved protein, agronomic traits, and disease resistance will be distributed to the breeders in the Partner States and eventually utilized commercially.

c) If adequate training is given to a qualified East African, EAAFRO will be capable of operating its own maize genetics research program.

III. REQUIRED INPUTS FOR SUBPROJECT

A. EAAFRO CONTRIBUTION - See Table 1

B. USAID CONTRIBUTION - See Table 1

IV. CONCLUSIONS AND RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

The maize breeding methodology study is making a valuable contribution, especially to East Africa, but also to maize breeding all over the world. Other breeders have studied selection methods singly and in pairs, but the methods study being conducted at Kitale under USAID and EAAFRO sponsorship is unique in its wide scope. Nowhere else in the world has such a comprehensive study been made, comparing a number of methods at the same time over a range of environments. However, it is still incomplete and a great deal of its value would be lost by premature termination. It is apparent that the breeding population spin-off has already made a valuable contribution to the breeding programs of the Partner States and is now being used in commercial varieties and hybrids. Capable supporting staff and adequate physical facilities make the continuation of this project feasible and highly desirable.

B. RECOMMENDATIONS

1. It is recommended that USAID support of the Maize Methodology Research subproject be continued for an additional 2 years. This would permit completion of the selection cycles for the major experiments. Evaluation of these experiments would continue.

2. Since the methodology research would not fully occupy the time of the USAID technician it is recommended that a limited breeding program to incorporate the hard endosperm opaque-2 be gradually phased in. Maize populations with improved protein quality, disease resistance and superior agronomic traits would be developed utilizing the improved populations available from the breeding methodology study.

3. Work on this subproject should be closely coordinated with the proposed protein laboratory and the maize low altitude disease resistance project.

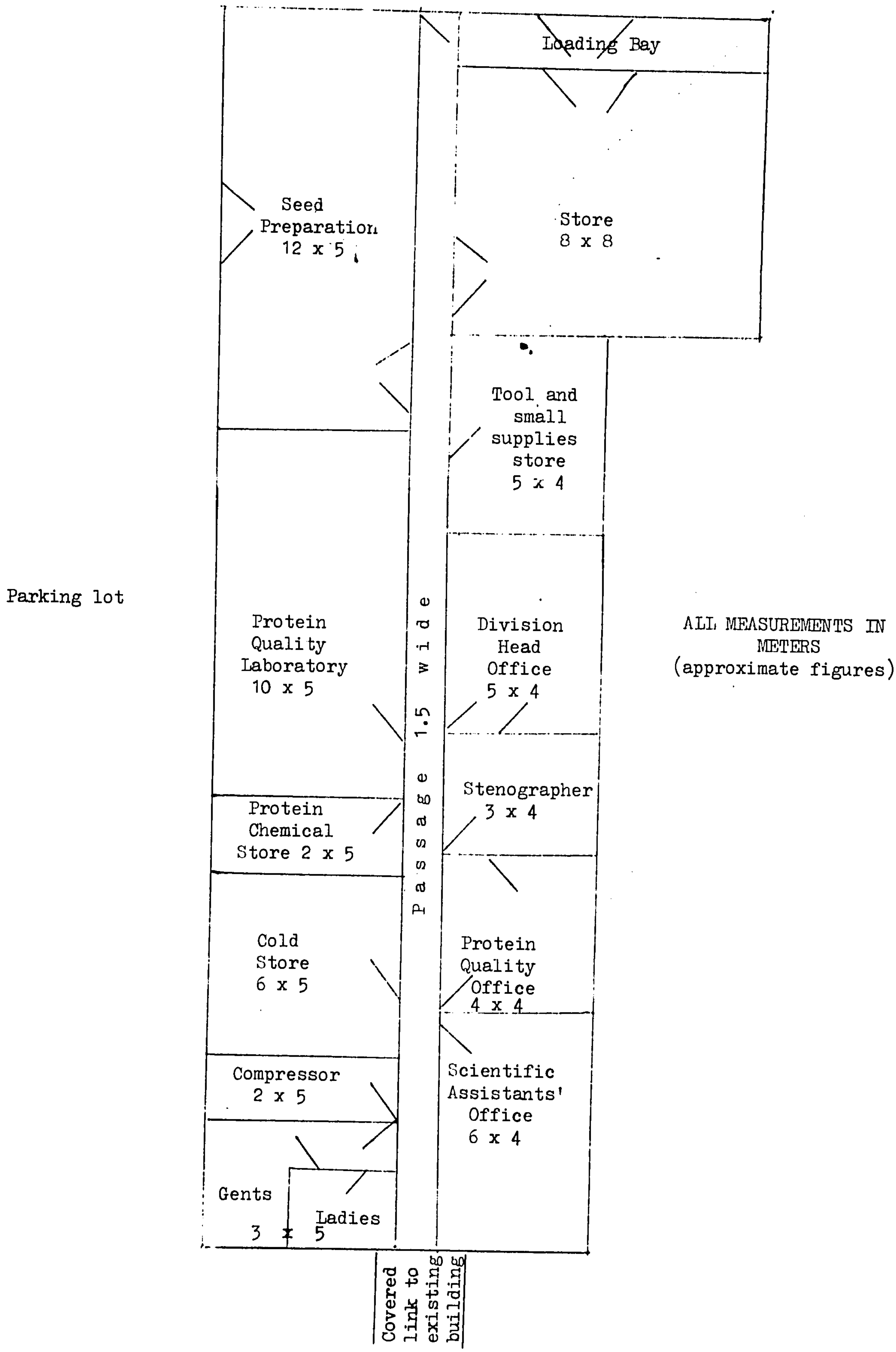
4. It is recommended that at the end of two years (early 1977) a review to be conducted to ascertain the feasibility of additional assistance to the hard endosperm opaque-2 program which will have been initiated.

5. No effort should be spared to effectively train East African counterparts.

TABLE 1 TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR CONTINUATION OF MAIZE BREEDING METHODOLOGY STUDY

Input	Time and Cost		Total by Category		Source			
	Year(1)	Year(2)	USAID	Others	EAAFRO	AID	Partner State	Other
	$	$	$	$				
Personnel								
(1) USAID Technician	50,000	50,000	100,000			X		
(2) Research Officer Trainees	6,200	6,200		12,400	X			
(1) Scientific Asst.	2,400	2,400		4,800	X			
(3) Lab.Assistants	3,300	3,300		6,600	X			
(12) Auxillary staff	7,700	7,700		15,400	X			
(1) Clerk	1,100	1,100		2,200	X			
(1) Stenographer	1,500	1,500		3,000	X			
(2) Drivers	1,700	1,700		3,400	X			
Casual labor	2,700	2,700		5,400	X			
Participant Training								
(2) Research Officers Training in US	20,700	18,000	38,700			X		
Commodities								
Machinery	21,000			21,000	X			
Moisture Tester	700			700	X			
Pickup	5,700			5,700	X			
Planter 4 now	2,000		2,000			X		
Moisture meter	200		200			X		
Desk Computer	3,500		3,500			X		
Land and Structures								
(1) Senior staff house	10,000	10,000		20,000	X			
(1) Intermediate staff house	4,500	4,000		8,500	X			
(13) Junior staff houses	13,400	10,000		23,400	X			
(3) Laboratory/office facility	70,000	70,000		140,000	X			
Building sites approx. 3 acres	1,080	1,080		2,160			X	
Travel and Per Diem								
Outside East Africa	2,150	2,150		4,300	X			
Within East Africa	1,450	1,450		2,900	X			
Consumable Supplies	7,500	7,500		15,000	X			
TOTAL FOR PROJECT			144,700	296,860				

SKETCH OF GROUND FLOOR PLAN FOR NEW OFFICE/LABORATORY EAAFRO KITALE SUBSTATION



STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT B - CROPPING SYSTEMS FOR MARGINAL RAINFALL AREAS

I. BACKGROUND

A. PAST

Population pressures are forcing unprecedented numbers of people to live in areas where the production of annual food crops is limited severely by lack of available moisture. Kenya officials estimate that population in these areas is growing at a rate of 3.1 to as high as 10% per annum. History, shows that crop failures have occurred periodically in these areas, but they affected few people, so were manageable. However, the areas involved are far flung, with limited transport and communication and the physical and economic difficulties of feeding the people in low production years are rapidly becoming insurmountable with increasing population. Since the respective Governments involved believe it best these people remain in agriculture rather than migrate to the urban centers which are ill prepared to receive them, development efforts to support them without relief are well justified.

Thus the goals are to determine cropping systems capable of bringing marginal rainfall or "medium potential" areas to the subsistence level in food crop production, and insofar as possible, to bring them to the point where they contribute to the economies of their respective States.

A rough concept of the situation and its relative importance to each of the EAC States may be seen in Table 1. (From "East Africa, its people and resources", Oxford University Press, 1969).

Table 1 - Percentage of land area receiving selected amounts of annual rainfall in four years out of five.

Rainfall	Kenya	Tanzania	Uganda	Remarks
Over 30"	15	51	78	Historically the areas of high population and crop production.
20 - 30"	13	33	10	Areas of interest to this subproject.
less than 20"	72	16	12	Pastoral areas; irrigation required for crop production.

The three rainfall areas described in Table 1 are akin respectively to the local classification of "high, medium, and low potential" areas. However, the true potential of an area for crop production requires consideration of more than annual rainfall total alone, as will be discussed in the proposal for a research program.

The low percentage of land in Kenya which receives rainfall exceeding 30" and the high percentage receiving less than 20" explains the need felt by the Government of that State to pursue research on cropping systems for the medium potential areas on a more intense level than is presently contemplated in the other States. Hence the Government of Kenya is preparing to establish a field research station and a team of scientists for this purpose. It will be shown that this complements rather than conflicts with the present proposal. Although fifty-one percent of land in Tanzania falls into the high rainfall category, fully two-thirds of the remainder is found in the 20" and 30" or marginal rainfall classification. The necessity of developing capability of the sort described in this statement is made even more critical to the interests of Tanzania because of their recent decision to relocate the national capital within the marginal rainfall area at Dodoma. Additionally, the proper location and management, including cropping systems, of Ujamma villages prompts interest and support for this effort.

Although Uganda has a relatively small proportion of marginal rainfall areas (about 10%) this becomes significant when one considers the need to provide opportunity for persons outside the presently developed agricultural areas.

B. PRESENT SITUATION

1. Success of Related Work to Date

Rainfall and evaporation data have been recorded for many years throughout the Partner States. In general these data have been reliable and adequate for most purposes. The evaporation data will need to be adapted to fit the crop production needs of agriculture because evaporation pans are typically located in a small grassed plot that is allowed to die-back during the dry season. Calibration of these data are possible by obtaining evaporation data from adjacent pans at a few locations where the grass is irrigated and kept green.

Soils data have been collected and soils characterized most completely in the areas of high productivity and principally as a basis of soil fertility recommendations. Some data on soil depth and water holding capacity are available but most soils of East Africa have not been so characterized and mapped.

Soil survey team leaders should be encouraged to report soil moisture holding capacity measurements for the full depth of the soil profile up to 3 meters.

Considerable research has been reported on cultivation practices that favor infiltration and retention of rainfall as soil moisture in East Africa and elsewhere in the world. Although a great deal is already known about soil conservation practices in Kenya, there appears to be a certain slackness in application in areas such as Katumani. The team consider it of vital importance that the utmost effort be made to ensure that what is already known is applied and that further research on this problem is carried out.

Studies of ox-plowing and other intermediate technology for the relatively extensive agriculture that will be characteristic of the marginal rainfall areas is also underway at various places in the Community. Such studies should be followed carefully and their findings included in the overall planning and eventual integration of the marginal rainfall lands research into a technically complete package of recommendations.

Crop responses to soil moisture are understood on a qualitative basis and lead to recommendations to grow "drought resistant" crops in the marginal rainfall areas. Such recommendations have been useful but inadequate for the construction of a prediction system to reduce the crop production risk in these areas. Detailed quantitative studies for the various crops are needed and are a basic part of this proposed experimental approach.

2. Constraints to Food Crop Production in Marginal Rainfall Areas

a) Technical Constraints

Ambrose has defined the land areas under discussion as 'Those areas where the production of annual field crops is limited severely by lack of available moisture but where the use of out of the ordinary conservation methods and specially adapted crop varieties would make crop production sufficiently reliable for an increased population to be carried'.[1]

Thus rainfall, both amount and distribution is a major constraint on production of food crops. Producers cannot change the rainfall of the region as Berry, et al point out,[2] but must adapt practices to efficiently use that rain which falls. A continuing data need is the measurement of the rainfall and a characterization of its frequency with as much precision as possible for predictive purposes. Indications are that such data are adequate in the marginal rainfall areas although more stations may be needed.

Retention of rain without runoff and its storage in the soil have given rise to a series of technical innovations under conditions of low rainfall. Among the techniques widely used are special tillage practices to increase infiltration, terracing and the use of contour tilling to hold the water on the soil, the development of micro-watersheds to facilitate harvesting of water for use in adjacent areas and weed control to conserve water for the crop. It is important that such practices, developed from other research be incorporated into the proposed research project and its extension into production areas.

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[1] Ambrose, H.B. "The case for intensified agricultural research in the medium potential areas of Kenya".

[2] Berry, L., T. Hawkins, R.W. Kates, L. Maki, and P. Porter "Natural hazard research on human adjustment to agricultural drought in Tanzania, pilot investigations. Research Paper No. 13, Bureau of Resource Assessment and Land Use Planning, The University of Dar es Salaam, November 1972."

Critical to the success of crop production practices under conditions of marginal rainfall are soil characteristics and the topography of the land. Soil texture, water holding capacity, depth and structure are physical characteristics that must be understood to construct a rational management system. Data on these characteristics are incomplete for vast portions of the marginal rainfall areas although a few quite adequate soil surveys have been done. Information on soil depth and the water holding capacity of the soil provide data on the amount of water available in the soil for plant growth. The experiment planned will use this soil water information as a key element of data needed to predict the probable success of food production in the marginal rainfall areas and for the development of cropping systems.

A thorough understanding of water utilization by food crops is also necessary before prediction of crop growth and yield response is possible. This constraint will be the subject of research and will be investigated for several food crops, especially those considered most adapted to the marginal rainfall areas. The pattern of root system development, crop water requirement, the proportion of soil water extracted and the response of the crop to water deficits at developmental stages are characteristic of each crop species but they are imcompletely understood under East Africa conditions. Once these relationships have been established by the planned research program the plant response can be predicted for any combination of anticipated moisture regimes furnished to the crop, and appropriate cropping systems can be determined.

Great Plains Agriculture in the United States of America may serve as an example of how management has developed strategies to cope with the constraint of limited water under natural precipitation as an illustration of how the proposed research plans could lead to management innovations in East Africa. There are important differences in climate, economic and social factors and the availability of technology between the two agricultures that will not be considered in development of the example. In addition it will be assumed that cultivation and conservation measures will maximize the retention and storage of soil moisture.

Soil moisture considerations directly determine whether or not a farmer in the Great Plains will plant a crop or wait for the next cropping season. Factors involved are a knowledge of the expected precipitation, the amount of soil moisture and the moisture needs of the crop under consideration. If there is insufficient moisture in prospect for the crop a decision not to plant is warranted. If sufficient moisture is possible the crop is planted. U.S. farmers have information available to them that lets them evaluate these factors with some precision. Rainfall records are known and soil moisture depth in the root zone is translated readily into inches of water. The decision is relatively easy because climatic restraints on season limit crop selection possibilities and the response characteristics of adapted crops are known from experiment and confirmed by years of experience. In East Africa the relationship between depth of soil moisture and the water available for plant growth needs to be established by experiment. Although physical methods have been used to approximate the value, the moisture in the soil available to plant growth is best estimated by actually growing plants on the soil.

The farmer in East Africa also needs to know more precisely the moisture requirement characteristics of the crops available. The information can be developed by experiment and functions developed that will permit prediction of plant response at any particular site where the evaporation from a class A pan is known. This information - moisture availability predicted from soil moisture and rainfall probability, moisture requirement predicted from evaporation probability, and the predicted response for a food crop species will permit rational evaluation of alternative systems of cropping. Planting dates also can be chosen using soil moisture information and an estimate of the time of probable onset of rainfall. For example, the amount of moisture stored in the soil would determine the time of planting in advance of the most probable onset of rainfall. A further item of information that is presently unavailable for management decision is the rate of planting of a particular crop that is appropriate under conditions of marginal rainfall. This information will be developed by experiment and made known as developed for each crop. A final management variable of use to the farmer that will be developed by experiment will permit the intelligent choice of crop variety and combinations of crops in cropping systems.

Constraints on food crop production in the marginal rainfall areas include the control of insect and disease and other pests such as wild animals and birds. Only as existing technology is extended by National Governments by supporting extension inputs into the production area can these hazards be reduced or eliminated. A special case should be made for the control of weed pests. Their competition for soil moisture must be continuously controlled as the storage and control of soil moisture is vital for crop growth. It is important that producers realize how necessary moisture conservation practices are to successful production under conditions where moisture is the factor limiting crop yield.

Farm units in East Africa are typically small-scale labor intensive operations. This reflects a rational response to resource (land, labor, capital) prices in the high potential areas of East Africa in which labor is relatively less costly than either land or capital. However, it is necessary to re-examine the efficiency of these resource proportions in the marginal rainfall areas where land is relatively more abundant (lower price) than it is in the high potential areas. The latter condition should result in larger quantities of land being used per unit of labor or of capital. However, it appears that physical strength and the availability of family labor, expecially in critical times of tilling, planting, weeding, and harvesting may place constraints on the amount of land which can be tilled successfully with labor intensive methods borrowed from the high potential areas. Thus, without some form of intermediate technology which permits the farmer to respond to a lower relative price for land it may be impossible to stabilize or increase production in the marginal rainfall areas of East Africa. The main constraint to be overcome in adapting technologies is to find a means for transforming successful technologies of agriculture in arid areas of the world into some intermediate form and conveying their water and labor conserving features into a package which is within the reach of East African farmers. The ideal intermediate technology would remove any existing labor constraint which prevents expansion of the land base to a level which would increase productivity per worker to parity with farm workers in high potential areas where labor is fully employed. Additionally, it should provide means for accomplishing tillage operations, terracing and other management practices which result in maximum soil water conservation and retention.

b) Institutional Constraints

One of the most difficult problems in extending food crop production into the marginal rainfall areas which require technologies beyond the experience of the farmer, is providing them with relevant and reliable information to support their operations. A series of demonstration production units successfully employing recommended systems of cropping based upon accurate soil moisture and predicted rainfall calculations is needed. It is expected that a major part of EAAFRO's responsibility will be an intensive educational effort involving leaders of the subproject with governmental planners, agricultural leaders and educators and eventually dealing with all levels of the population to acquaint them with every detail of the technology of production on marginal rainfall areas.

It will be necessary to develop an action network in cooperation with the meterological service that will collect rainfall and soil moisture data and integrate such data into recommendations on dates of planting and appropriate cropping systems. Perhaps several choices of cropping systems could be made available with associated probabilities of success. Managers could then weigh risk with expected return according to personal taste.

3. Other Agencies and Donors Involved in the Subproject Work and Their Attitude toward AID Participation

a) International Organizations

FAO - No contact was made with personnel of FAO. It is understood that UNDP is fielding a soil survey team based at the Mlingana Research and Training Institute, Tanga, Tanzania. This input into the agriculture of Tanzania is sorely needed and if the depth and moisture holding capacities of Tanzanian soils are precisely mapped the input would have direct value to the proposed project. Dr. Wang'ati, of EAAFRO has indicated that he has been invited to make suggestions to the team leadership.

ICRISAT - No contact was made with ICRISAT in a formal way although some members of the team met Dr. Doggett at Morogoro, Tanzania. It was understood that negotiations between ICRISAT and the Faculty of Agriculture and Forestry, University of Dar es Salaam, Morogoro, Tanzania are proceeding on cooperative research pertinent to food crops production under marginal rainfall conditions. Emphasis seemed to relate to the introduction of drought resistant and drought escaping crops and possibly some plant breeding programs on those crops. ICRISAT input of drought resistant and drought escaping food crops varieties was also suggested in relation to research at the Katumani Agricultural Research Station, Machakos, Kenya. Input of adapted varieties of such crops would be a valuable contribution to this project. Tanzanian and Kenyan officials have indicated that they would assist in making linkages to facilitate such cooperation. Inputs from ICRISAT based upon their minimum tillage studies in India should also be encouraged.

b) National Organizations

Ministry of Agriculture, Tanzania

Officials in the ministry were supportive of any effort that would provide research data that would facilitate the development of marginal rainfall lands. The announced intention of moving the National Capital to Dodoma illustrates the Government's determiniation to develop these areas. Cooperation of a general nature was assured.

Faculty of Agriculture, University of Dar es Salaam, Morogora, Tanzania

A willingness to cooperate by providing land and physical facilities was expressed by the Dean. Technical support of the Department of Crop Science and Production in providing drought resistant and drought escaping sorghum, millet and legume varieties was also indicated. An effort should also be made to seek collaboration arrangements with faculty of the Soil Science Department as it was indicated that some of these faculty members are interested in the instrumentation of soil water research.

Agricultural economics evaluation and interpretation is also a possible input, particularly if Ford Foundation funding and other arrangements make the appointment of a senior agricultural economist possible.

Bureau of Research Assessment and Land Use Planning (BRALUP), The University of Dar es Salaam, Tanzania

Personnel of BRALUP have been doing surveys on very small scale maps of soils, hydro-economic zones, and of rainfall and evaporation in Tanzania. Also surveys of drought and human adjustment to drought and an assessment of photosynthesis and agricultural potential have been made. Most of these studies were not intended to be rigorous but when complemented with opinions of the staff of BRALUP would be helpful in planning the extension of the marginal rainfall results to planners and government policy makers in Tanzania.

Ministry of Agriculture, Kenya

Personnel of the Ministry have intensively studied the extension of food crop production into lands with marginal rainfall. They are in the process of designating a site for research in both animal and food crop production and assembling a research team. They are supportive of EAAFRO efforts to provide an expanded research effort and have indicated that they are prepared to extend research results to planners, government agencies and small holders in Kenyan agriculture.

c. Other Agencies

Department of Water Science and Engineering, University of California, Davis, California, 95616

Personnel of the Department are prepared to offer technical support to the project by serving as consultants or by providing the opportunity for persons associated with the project to become familiar with appropriate operational practices by visiting and working at Davis.

4. Relationships between EAAFRO and National Research past and present

As stated in the "Report of Research, Annual Report, 1972, EAAFRO":

> "EAAFRO is not concerned with purely local problems unless specifically asked to investigate them by a National Department. Likewise, EAAFRO is not an advisory organization as such, though scientific advice and guidance are readily given by the research staff on request to National and other research workers".

This seems to be particularly true in the division of Agricultural Physics and Chemistry. The division has sponsored research in the recent past on hydrology of several catchment areas and included studies of the effect on water balance of changing the types of vegetation and ground water recharge. In addition research on agricultural meteorology, soil physics and water-plant relationships have been a part of EAAFRO's contribution to a physical assessment of agricultural capabilities in East Africa. Such data have typically been furnished to National planning agencies. Our investigation has confirmed their expertise in these areas of research. They have demonstrated that such confidence is well founded. EAAFRO has also supported national plant breeding programs by furnishing expertise in demonstrating plant breeding methods and in providing superior germ plasm. Such expertise is valuable in the evaluation of national breeding efforts to obtain drought resistant and drought escaping varieties of food crops. This collaboration with breeding projects is particularly important in demonstrating those properties that make for successful drought resistance or drought escaping ability.

5. The Role of EAAFRO in the Proposed Marginal Rainfall Areas Research Project

1. Basic research on growth characteristics of major food grains and legumes to quantify their influences on crop water requirements and on the actual water regime, and to quantify yield responses to water deficits in different growth periods.

2. Development of the capability to combine researched crop characteristic findings with planting site (marginal rainfall areas) measurements of climate and soil to predict the water requirements, the actual water regimes, and consequent crop yield expectations.

3. Development of the capability to predict the time (growth stage related) pattern of water deficits and their impacts on yield for any combination of crop, climate and soil, and to utilize this estimate to further predict the optimal application pattern for any supplementary irrigation water supply which may be available.

4. Serve as the center for data collection, computation and interpretation. This includes all available meterological and soils data, plus the research findings at all levels in this and related studies.

5. Serve in the role of coordinator of and liason between all research activities related to food crop production in the marginal rainfall areas by agencies, whether EAC, international, national governments, universities, or other.

6. Serve as an active disseminator of meteorological, soil, and crop information and of recommendations for field application of research findings which have reached the stage of usefulness. The suggestion here does not include village level extension, but rather the active conveying of useful information to national planners, national experiment station staff, personnel of the agricultural extension services and soil conservation services, and to personnel of research related agencies such as UNDP-FAO, ICRISAT, IITA, WORLD BANK, etc.

7. Eventually to serve as computational and output center for annual cropping system recommendations based on soil water monitoring at key sites in the marginal rainfall areas and long range weather forecasting. Still later this capability may be transferred to marginal area centers as a continuing service to agriculturists affected.

6. Brief Summation of Previous Studies Made on this Area of Work

The subproject team reviewed publications authored by EAAFRO scientists in this area of work. The papers were judged to be of excellent quality and dealt with all aspects of the research activity that are called for in this subproject. Included were lysimeter studies on water use efficiency of maize and beans and two papers on lysimeter studies of the water use of tea. Other relevant papers included ones on the use of the neutron moisture gauge, the rational selection of crops for areas of marginal rainfall, water conservation by fallowing, rapid calculation of estimates of evaporation, and transpiration from short grass.

7. Views of the Project Team Regarding EAAFRO's Capabilities, Direction and Viability in Carrying Out this Subproject

EAAFRO has a long distinguished tradition in the area of agro-meteorology as judged by the number and quality of publications in this subject matter area. Facilities seem to be well laid out and maintained. Modern instruments are available and the experiments are well instrumented. Serious difficulties in recruitment of qualified local officers and trainee officers in the recent past has apparently hindered the research program because of inadequate staffing. There is evidence now, however, that more persons are enrolled in appropriate education programs and there is assurance that the counterpart positions can be filled by qualified local officers. It is felt that a program that will maintain EAAFRO's reputation as a premier research institution in the area of agrometeorology will make recruiting of outstanding local officers easier.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1. a) To develop recommendations for cropping systems which will both increase and tend to stabilize food crop production levels in the marginal rainfall areas of East Africa. The recommendations developed will be based on:

1. An ability to predict the water regime which a given crop (or cropping combination) will experience when soil, climate and cropping season are specified.

2. An ability to predict the yield of a given crop (or cropping combination grown in a specified water regime.

b) To develop recommendations for maximizing the crop yield response to supplementary irrigation water whenever it is available.

c) To establish EAAFRO in a coordinating role with agencies whose activities relate to food crop production in marginal rainfall areas. Specific areas of concern in this role include:

1. An ability to adapt soil tillage and conservation practices which will maximize water retention, infiltration and conservation in the cropping system.

2. An ability to use with full advantage materials from plant breeding programs concerned with developing drought escaping and drought resistant varieties of the major food crops including sorghum, food legumes and millets.

d) To establish in EAAFRO the capability for translation and further refinement of data output from the marginal rainfall experiment for utilization by farmers, agricultural development planners and the directors of private and public agricultural programs in East Africa. Specific areas of concern include:

1. A determination of social and economic constraints in implementation of cropping system recommendations.

2. Appraisal of alternative strategies for implementation and assessment of cropping system recommendations.

2. Subproject Relationship to Other Subprojects

As the preferred cereal crop in East Africa, maize requires full research attention in all aspects. Thus other subprojects relating to development of new maize varieties (breeding methodology), their disease resistances, and their nutritional qualities (protein laboratory), all are expected to make valuable contributions to the subproject on marginal rainfall areas.

3. Technical Feasibility

The EAAFRO program is to be modeled after studies begun at the University of California at Davis in 1969, and which are currently being carried on jointly by the *CID Universities. The objective is to quantify the growth characteristics of principal crops which influence their water use and yield expectations.

*A consortium of the Universities of Arizona and California and Colorado State and Utah State Universities. The acronyn "CID", meaning "Consortium for International Development" has been adopted.

Different crop types and growth patterns result in different water requirements, different patterns of actual water uptake from the soil, and different yield responses to water deficits in different growth stages. It should be noted that the pertinent crop growth characteristics may differ between varieties as well as species.

Once experimentally quantified, the crop characteristic information may be combined with planning site measurements of climate and soil to predict the water use and yield expectations. The method also specifies the most efficient way to utilize any available supplementary irrigation water.

Examination of the physical facilities and staff of EAAFRO, and of government and university research stations in the marginal rainfall areas, and of the spirit of cooperation which exists between all of these and between the Partner States leads the project team to conclude that the subproject is technically feasible.

The subproject is an action proposal designed to begin producing information upon which to base field recommendations within a period of two years, which includes time for gathering and training of staff, establishment of research equipment, and the development of recommendations for a single crop from the first year research results.

The proposed research program is to work simultaneously at four levels as follows: (See Table 2)

1) A conceptual guidance and scientist training level at the University of Calfornia at Davis.

2) Basic research on pertinent growth characteristics of principal crops at EAAFRO, Muguga.

3) Applied research to thoroughly test the transferability of findings made at Muguga to the marginal rainfall environment, and to extend the research effort to spacing and varietial trials. Possible sites for these experiments are Katumani in Kenya and either Morogoro or Ilonga in Tanzania.

4) Farming level observation trials to test the predictive capability of the method at the point of use, and to further study effects of yield and water use influencing factors such as plant spacing and fertilization. Two such trial sites are contemplated in each Partner State. These may be located either on national or university stations in marginal areas of particular interest for development.

Each research level above has its own requirements with respect to location, climate, soil, research facilities, procedures, equipment, and personnel. An enumeration of the various levels of research, site and experiment requirements and other pertinent inputs are listed in the following table.

AN ENUMERATION OF SITE AND EXPERIMENT REQUIREMENTS FOR EACH RESEARCH LEVEL IN THE MARGINAL RAINFALL SUBPROJECT

RESEARCH LEVEL	LOCATIONS	MISSIONS	NO.OF SITES	CLIMATIC REQUIREMENTS	SOIL REQUIREMENTS
I	UC, Davis	Conceptual guidance and Scientist level training in experimental techniques applicable to this new type of study; Consulting as required	1	Summer, no rain (experiments irrigated for full water regime control)	Deep (3m), open structured soil w/moderately high water holding capacity
II	Muguga	Basic research on the characteristics of major food grains & legumes which influence crop water regime and yield response; Development of capability to predict crop water regime, crop water deficit sequence, & expected yields in any climate-soil context.	1	Dry season, minimal rain (irrigation for water regime control)	Depth 3m, open structure, moderately high water holding capacity
III	Major National Government Facility in Marginal Rainfall Areas	Applied research to recheck the Muguga findings on crop responses, and assure their applicability to the marginal rainfall environment. Additionally, trials on different varieties of the current test species, & on plant spacings may be conducted at this level.	2	Rainy season (Irrigation to be developed for attainment of different water levels)	Depth 2m, Structure OK, moderately high water holding capacity
IV	National Government Stations in Areas of particular interest and applicability	Observation Trials at the Farm Level to check the accuracy of prediction and to study related factors such as plant spacing and fertiliser needs.	4	Rainy season as it occurs	Representative of important farm soils in the area

EXPERIMENTAL DESIGN	LAND AREA REQUIRED	NOS. OF TREATMENTS & REPLICATIONS		NOS. & SIZES OF PLOTS	NATURE OF TREATMENTS
Varied	2 Hectares	Variable	4	Variable	Varied water regimes
Randomized Block Design for field plot experiments; environmental control plantings in Lysimeter field	2 Hectares (100m x 200m)	8 in field plots plus lysimeter	4	32 (10m x 20m)	ET DEFICITS IN 3 Growth periods and in all combinations, plus well watered Lysimeter for ET MAX (All factors other than water quantity and timing to be non-limiting at Research Levels I, II and III)
Latin Square	0.6 Hectares (60m x 100m)	4	4	16	a) No ET DEFICIT (ET MAX) b) Mild ET DEFICIT c) Moderate ET DEFICIT d) ET ACTUAL as it occurs
Single Observation Blocks	0.36 Hectares (60m x 60m)	8	1	8 (10m x 20m)	Various, e.g. 2 Blocks Unfertilized Moderately fertilized 4 spacings in each block; 100%, 80%, 60% & 40% (Plants for Y Max)

MEASUREMENTS TO BE MADE

Various

Climate: (Daily) Rainfall; class A Pan evaporation (irrigated grass site vs dry grass site); Radiation; sunshine hours; temperature; humidity; windspeed.

Soil & Water: 1) water holding capacity of soil layers measured following pre-plant irrigation and drainage of field plots. See below for methods.

0-15 cm – Gravimetric methods OR estimate ½ of 15-45 cm value

15-45 cm and additional 30 cm layers to 285 cm if soil depth permits, using a neutron probe.

2) soil water content of field plots – as above, weekly all season.

3) water depths applied in irrigations – meter on perforated pipe system.

Crop: 1) Plant population and spacing achieved – following emergence – field counts

2) Total dry matter production at start of each major growth period and at harvest – destructive sampling of plots outside yield and soil water measurement area.

3) Grain yield, protein content & 1000 grain weights at harvest.

4) Other desired measurements, e.g. plant height, % ground cover, leaf area index.

Climate: (Daily) As in II above

Soil & Water: As in II above

Crop: As in II above

Climate: Rainfall; class A pan evaporation (Dry Grass site); Other measurements as desired

Soil & Water: 1) Water holding capacity of soil layers following wetting and drainage. Note no irrigation is provided so can be done after heavy rains.

2) Actual soil water content at planting, as above in II(1) but without pre-plant irrigation.

3) Soil water content as in II(2) above

Crop: As in II above.

REMARKS

Scientist training for this project should be in the summer of 1975 starting as early as possible. Support for their activities will require negotiation with the UC Davis administration. The Davis Project Principal Investigator is Dr. R.M. Hagan of the Dept. of Water Science & Engineering.

New facilities required at Muguga include an irrigation capability, i.e. a new borehole, pump and perforated pipe system for 2 + hectares of land, a moderate size lysimeter (3m x 3m x 2m depth) 3 depth moisture gauges with scaler units and installation of 2 new class A Evaporation Pans in a large enclosure half planted and maintained in irrigated grass year around (when rainfall is lacking). Spare parts and interchange ability of all depth moisture gauges (neutron probes) is essential.

Facilities at the major experimental stations include an irrigation capability. Class A evaporation pan installations such as those at Muguga must be installed and maintained. Rainfall must be measured.

Transportation of a technician with neutron probe and other equipment to these sites on a weekly basis will require the provision to EAAFRO of three vehicles and an adequate provision for travel costs.

4. Beginning and Ending Point with Intermediate Targets for USAID Assistance

Aid assistance will begin with staff recruitment. The key person as identified in Table 3 is the USAID technician Agro-meterologist. Staff recruitment should be completed within 1 year from the date of initiation of the project. The selection of officer trainees will be conducted concurrently with staff recruitment and they should be selected and have completed their training 27 months after project initiation. Fifteen months after the initiation of project support at least one of the laboratory technician counterparts should be available to gain on-the-job experience by assuming a role in the operation of the subproject. All counterpart personnel except the laboratory technician should be involved in work on the project 24 to 27 months after project initiation. Transition from training to full responsibility by participation in the work of the project should begin for Agro-meteorologist, agronomist and agricultural economist trainee counterparts 36 months after project initiation and should be complete at the end of 48 months.

Recommendations relative to cropping under conditions of marginal rainfall will first be possible at the end of the second year experiment cycle 1 and should be developed with greater applicability with the completion of each four iterative cycles of the experiment. Each cycle will require approximately 15 months. The first cycle should begin about 9 months after project initiation and the fourth cycle will begin at the end of the fourth year coincident with the termination of AID assistance. However it is anticipated that the Agronomist and Agricultural Economist will overlap at least 6 months of the fifth year because of their later posting date. The "late" departure of these people is symetric with the early arrival of the Agro-meteorologist and should result in full evaluation of cycle three and careful overview of the fourth cycle. AID assistance should terminate at the end of the four year term of the AID technician who was last appointed.

5. Importance of the Subproject to the Development of Food Crops in East Africa

Increased production and the stabilization of food crop production in areas where rainfall is highly variable and frequently severely limiting depends on an ability to predict (within a reasonable range) (1) the water regime a given crop variety planted on a given date will experience, (2) the water requirements for a maximum yield, (3) the water deficit which the crop will suffer, and (4) the reduction in crop yield below maximum which will result from the expected water deficits. The yield reduction must take into account both the total seasonal water deficit and how the deficit occurrences relate to specific crop growth stages which differ in their sensitivities. Such predictions require (1) research on those crop growth characteristics which influence crop water requirements such as the pattern of canopy development, the ability of the crop root system to exploit soil water, and the yield response patterns to water deficits in given growth periods and (2) planting site measurements of climate and soil. The proposed research procedures and planting site measurements are unique at present to a long term study begun at the University of California at Davis, which is presently being carried on (with OWRT funding until 31 December, 1975) by the four CID Universities, which are doing advanced testing of the concepts and prediction methodology. It should be noted that the specific type of research on crop characteristics recommended for EAAFRO has only been carried out at University of California at Davis. However, the EAAFRO study also includes planting site testing of the prediction method, and finally, presentation of the findings in the form of recommendations for individual farm level application.

The farmer will be furnished data to help him decide what crop (and variety) to plant and whether or not to plant it, the optimal planting date, and the plant spacing and fertilization rate which will maximize his yield. He also needs information to decide on other practices such as soil preparation and tillage methods, weed, and pest control measures, and a sequence of cropping that will maximize productivity from his farm. These decisions today are based almost wholly on trial and error by farmers in the marginal rainfall areas. This is not satisfactory in planning land development in the nations of East Africa which are experiencing a rapid influx of population into areas of low rainfall that must become self-sufficient in a reasonable time in circumstances which at best are discouraging to farmers.

An important point not as yet discussed is that the prediction ability sought also implies the ability to specify precisely the crop characteristics most suited to the marginal rainfall areas. Plant breeders and those selecting among available plant materials require this information, as do agronomists planning cropping systems of maximum efficiency. The characteristics used by agronomists in designing cropping systems can be illustrated by data developed in the University of California at Davis experiments, shown in Figure 1 for maize, sorghum and beans. The graph shows the relative yield reduction in response to moisture deficits over the season. The line so plotted represents the "yield reduction ratio" and is characteristic of a particular crop.

The yield reduction ratio shows the minimum percentage reduction in yield resulting from each percentage point of seasonal ET deficit. Still greater yield reductions may result from ET deficits which occur in critical stages. The proposed research determines both yield reduction ratios and relative sensitivities of different growth stages for each crop type studied. Yield reduction ratios may differ between crop varieties as well as species. In fact a low yield reduction ratio is a characteristic to be sought when selecting or breeding for drought resistance.

Yield reduction ratios such as those shown in Figure 1 are the key to selecting either the most productive or most profitable crops to grow in specified water supply circumstances. Figure 2, which is based on Figure 1 compares the actual grain yield expectations for maize, grain sorghum, and pinto beans under a wide range of seasonal crop water supply levels. All that is needed to transform the yield reduction ratios in Figure 1 into actual "water production functions" such as those in Figure 2 is to estimate the maximum values for grain yield and seasonal ET when water is not limiting production. In Figure 2 these maximum values are represented by small circles. Maximum values of yield and ET depend on the crop type and variety, and the climate where it is to be grown. Development of methodology for estimating these values is an integral part of the proposed research.

Figure 2 shows the maximum yield of beans can be achieved at the lowest ET level of any of the crops. Sorghum requires somewhat more water to achieve its maximum yield, and maize requires the most water but has the highest yield potential when water is not limiting. Data from the UC Davis experiments further reveal that maize is particularly susceptible to yield reduction when water deficits occur during critical stages of growth. Beans and sorghum do not respond so critically to moisture deficits because their fruiting capability is not limited to a single ear. Sorghum has the capacity to tiller when moisture becomes favorable and beans can produce a new set of pods. It will be noticed that at a certain ET level (18.0 inches of water) the most productive crop shifts between maize and sorghum. Situations with less water available favor the growth of sorghum but with greater availability of water maize becomes the preferred crop. This is particularly true if irrigation is available and the moisture deficits that occur can be shifted away from critical times. Without irrigation sorghum may remain the preferred crop in conditions where moisture deficits have a high probability of occurring at critical times in the maize growth cycle.

Figure 2 illustrates how the proposed research may provide the basis for selecting among crops and varieties to satisfy subsistence level food requirements in different water conditions. It also provides the essential technical input necessary for economic analysis. When commodity prices and crop production costs are considered, Figure 2 may be transformed as shown in Figure 3.

In Figure 3 the net value of production per acre is plotted against seasonal ET. For purposes of illustration the figure incorporates the prices and costs which prevailed in the Central Valley of California in September, 1974 just after harvest. At that time the prices per 1000 lbs. stood at $65. for maize, $63. for grain sorghum, and $280. for pinto beans. The picture which emerges is that all three crops are about equally profitable when seasonal ET availability is approximately 15 inches. At higher water levels beans are most profitable, while at lower water levels grain sorghum is. When seasonal ET falls to 10 inches none of these three crops returns a net profit. Beans become unprofitable when ET falls below 14 inches, maize at approximately 12 inches, and grain sorghum at 10 inches. Given the capacity to predict ET in advance of planting makes it possible to choose the most profitable option. This is another of the proposed research goals, and involves development of a methodology for estimating both the quantity of water which a given root system will be able to extract from a given soil type, and the precise time sequence in which the extraction will occur. Thus the knowledge to be gained through research of the basic crop growth characteristics, the measurements of soil water characteristics and of climatic factors, and data on crop costs and returns all form useful and essential inputs to the development of cropping systems as envisioned in this subproject.

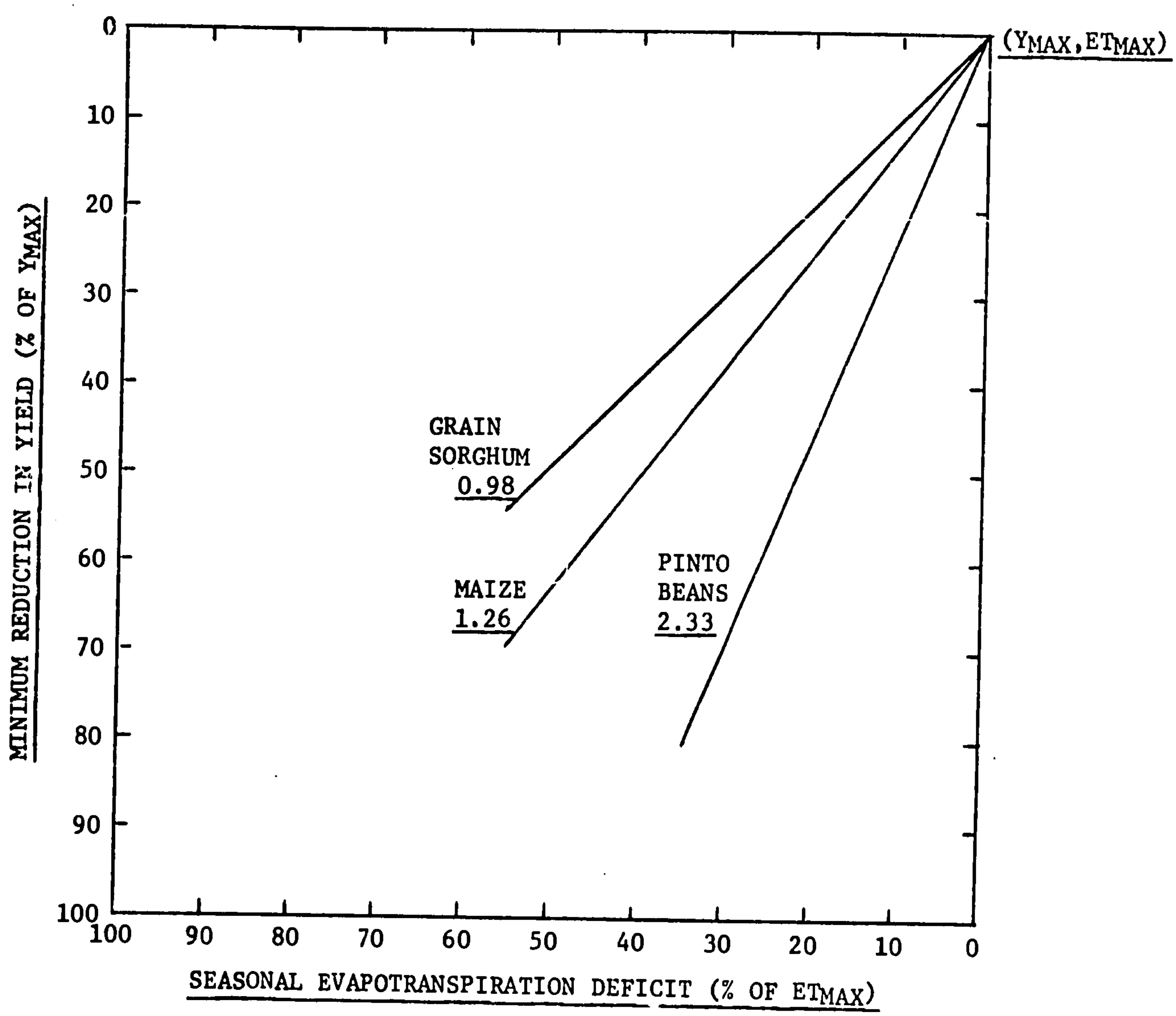

FIGURE 1 - MINIMUM RATES OF YIELD REDUCTION EXPECTED IN RESPONSE TO OPTIMALLY TIMED SEASONAL EVAPOTRANSPIRATION DEFICITS (RELATIVE VALUES). NUMBERS WITHIN THE FIGURE ARE "YIELD REDUCTION RATIOS".

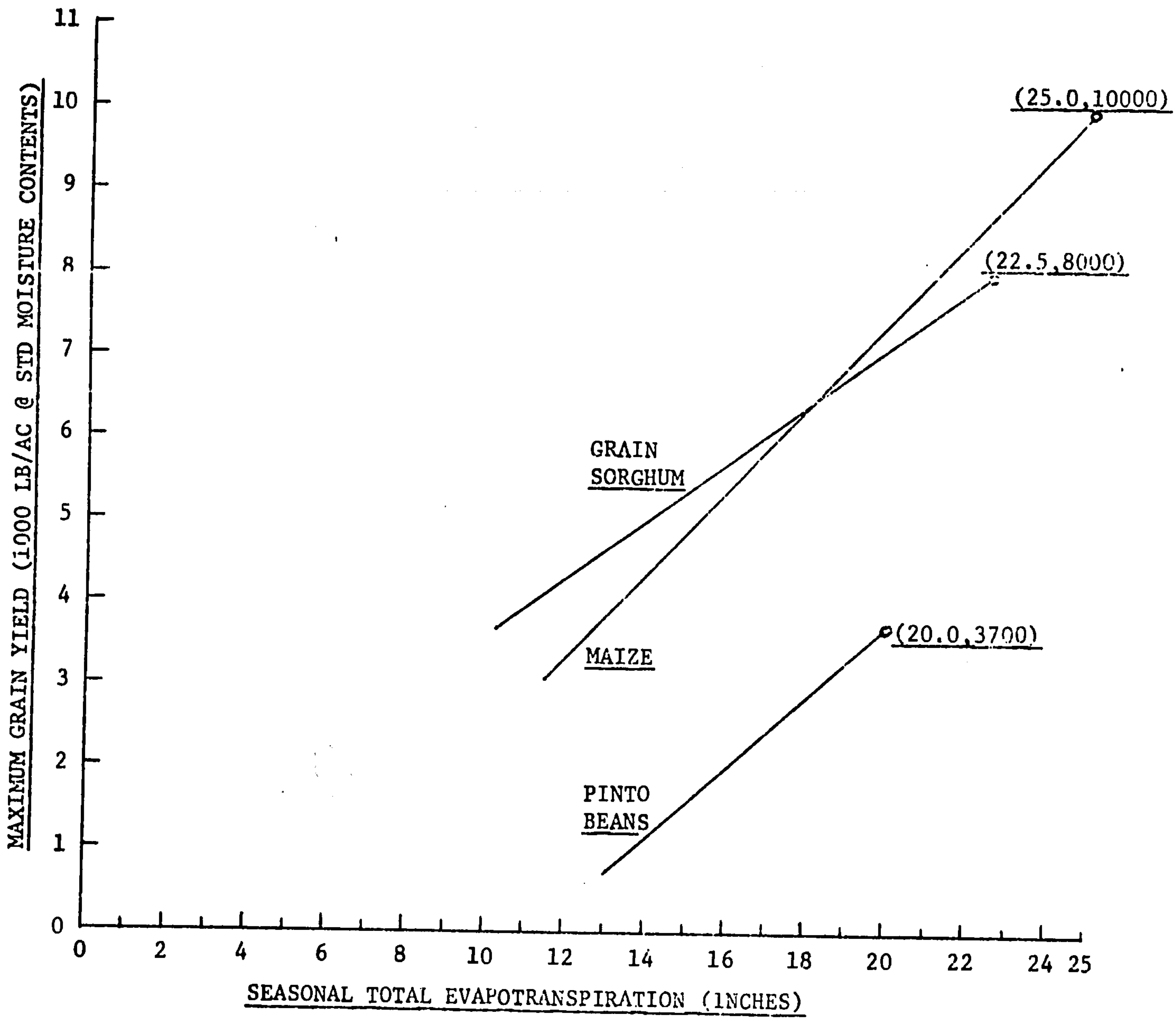

FIGURE 2 - COMPARISON OF MAXIMUM POSSIBLE YIELDS OF MAIZE, GRAIN SORGHUM, AND PINTO BEANS GROWN AT UC, DAVIS, CALIFORNIA UNDER A WIDE RANGE OF ET LEVELS.

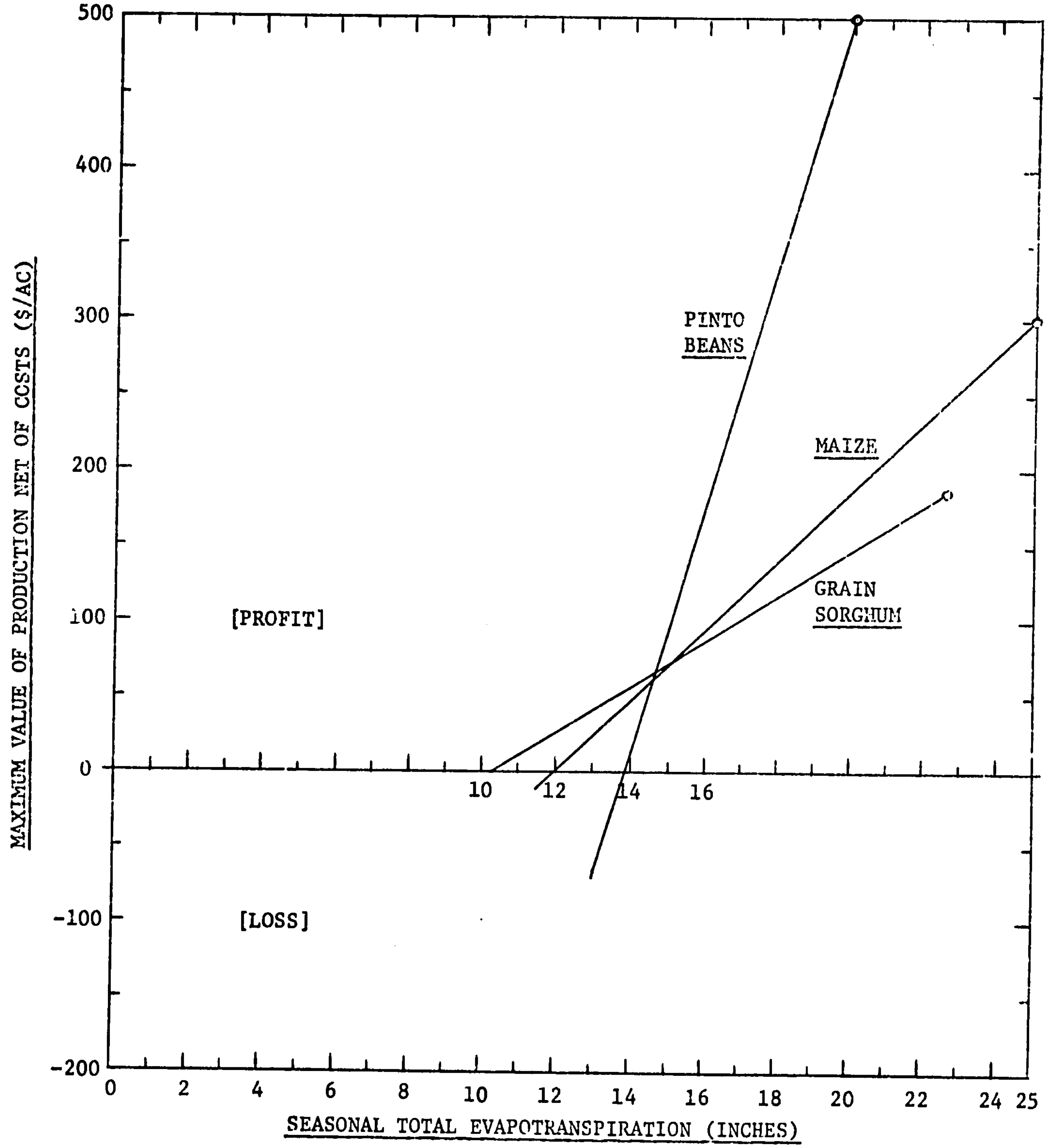

FIGURE 3 - COMPARISON OF NET RETURNS FROM MAIZE, GRAIN SORGHUM, AND PINTO BEANS GROWN AT UC, DAVIS UNDER A WIDE RANGE OF ET LEVELS. BASED ON COMMODITY PRICES AND PRODUCTION COSTS IN THE CENTRAL VALLEY OF CALIFORNIA ON SEPTEMBER 30, 1974.

B. EXPECTED OUTPUTS

1. Basic assumptions for the success of the project

a) The success of the subproject is absolutely dependent upon the integration of the data from all levels of the experiment into a yield reduction function characteristic of each food crop. A second assumption is that there will be a characterization of the soils so that their ability to deliver water to the plant is known. A third assumption is dependent upon the summation of the most probable climate with the soil moisture data to predict the most probable moisture regime for a cropping season. All of the above assumptions are primarily dependent upon the accomplishment of the objectives of the subproject.

b) Assumptions necessary for success beyond those dependent upon meeting the objectives of the experiment include the existence of a network that will monitor soil moisture in the marginal rainfall areas. This information will be necessary in making recommendations to farmers consistent with the moisture regime for the cropping season. It is assumed that there will be an aggressive extension education program that will provide data to farmers that helps them make decisions on timing of operations, selection of cropping systems and the selection of other inputs such as pest control and fertility practices to maximize production. It is also assumed that data on methods of tillage, and other conservation practices that maximize moisture infiltration and storage in the soil will be incorporated into the extension package of technology for the marginal rainfall areas. An investigation and development of an intermediate tillage technology that will equalize labor inputs per unit of crop produced between the marginal rainfall areas and the high potential production areas is also assumed.[1] This parity is necessary to stablize the population and to permit the development of supporting community institutions in these areas.[2]

An important assumption for the success of the project is that a range of crops are available for testing in the subproject experiments and that the most adaptable ones will be available to farmers in the marginal rainfall areas. Liason with breeding programs that have the capability of developing crops that have drought resistant and drought escaping characteristics is essential. Since agriculture in these areas will often need to sustain the population at a subsistence level attention to the nutritive value of crops is assumed. For example, high quality protein maize should be adapted to these areas.

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[1] Johnston, B.F. and P. Hopcroft "Notes on past research and the economics of small scale farming and cooperation in research and the dissemination of technical information". In Proceedings of Seminar on Cooperation in Agricultural Development in East Africa. January 13-20, 1975. Nairobi, Kenya.

[2] Mbithi, P.M. and C. Bar :r "The spontaneous settlement problem in the context of rural development in Kenya." University of Nairobi, IDS report for the World Bank African Rural Development Study 1973 (Original paper not seen. Team has had discussions with Mr. Mbithi).

Specifically, the input of Katumani composites maize from the EAAFRO breeding program and short season composites and hybrids from national program need to be included in the subproject experiment to provide a range of maturity types. Experience in other arid areas of the world suggest the need for crops more drought tolerant and more drought escaping than maize. An assumption of the project is that germ plasm from the EAAFRO sorghum and millet breeding project and from the National programs will be fully explored in the context of the subproject experiment. If liasion with ICRISAT is accomplished by the Partner States their sorghum and millet varieties should also be explored. A major effort should be made to develop resistance to birds into these crops.

Because of their unique contribution to nutrition and their wide range of adaptation to different cropping situations, food legume crops inputs must be made using the best germ plasm available. In addition to referring to the ICRISAT experience with legume crops and their collection of germ plasm it might be well to examine the collections and data on legume cropping systems that are being developed by CIAT, Cali, Colombia. A qualified consultant with experience in food legume cropping in areas of marginal rainfall could make valuable recommendations on this point and could also assist in analyzing cropping system data.

An economic analysis of the agriculture in the marginal rainfall area and an economic interpretation of the production functions that are developed from the project are an essential part of this project. This analysis would be a valuable input into forecasting for the purposes of Governmental planning. Evaluation of production implications would be required not only at the micro level, but for major intra-state areas, partner states and for the East African Community. Forecasts of production and prices would permit planning of such services as agricultural marketing, agricultural credit needs, fertilizer and agricultural chemical inputs into production and famine relief in case of severe drought. Basic to these forecasts would be the monitoring of soil moisture and climate in relatively homogenous regions. Economic interpretation would also assist the producer in making efficient resource allocation and management decisions and in planning purchases for each crop season. A qualified agricultural economist would provide a critical link in transforming project data outputs into a rudimentary cropping system, which inputs to the farmer, agricultural development planners and to the directors of private and public agricultural programs.

c) Evaluation of the rather unique methodology involved in this problem focused, multidisciplinary research is an attainable output that could have an important impact upon similar problems related to resources development. Scheduling of consultants was planned to ensure that this output of the subproject is made.

2. Predicted Benchmarks of Achievement

Achievement can best be judged during the life of the subproject against the following benchmarks:

a) The quality and completeness of staff recruited as USAID and EAAFRO personnel as judged against the job descriptions for the project.

b) The performance of counterpart EAAFRO technicians in staff development programs both in the United States and as participants in the research project at EAAFRO installations.

c) The development of a cropping system forecast capability which will furnish data inputs of value to government, and to agencies providing support service to agriculture and community development in the areas of marginal rainfall. Such data will flow to agencies as estimates of productivity based upon forecasts made by integrating soil moisture and climatic information with crop response data. Such forecasts of productivity when coupled with acreage estimates should provide a considerable degree of precision in estimating crop production in a particular area. The reliability of the forecasts would be a benchmark for assessing the project.

d) The release of cropping system data outputs to maximize farm production. Such data outputs must be specific enough to assist the farmer in making key decisions as to whether moisture is adequate to plant or whether fallowing for the season to store moisture is appropriate, date of planting, choice of crop and variety, and the rate of planting. As the experiment proceeds data on more complex decisions will become available that cover a wider range of crops, crop mixture and combinations of crops and crop mixtures into a unified system of cropping.

e) An evaluation of how well research findings of the subproject are integrated with recommendations from other agencies to provide a unified package of recommendations on cropping systems acceptable to farmers in the marginal rainfall area.

The time phasing of benchmark goals are indicated in phase with research activities as specified in Table 3.

TABLE 3 -- TIME PHASED SCHEDULE OF RESEARCH ACTIVITY AND RESULTANT OUTPUTS LEADING TO CROPPING SYSTEMS RECOMMENDATIONS

ACTIVITY	Year 1 Q1 Q2 Q3 Q4	Year 2 Q1 Q2 Q3 Q4	Year 3 Q1 Q2 Q2 Q4	Year 4 Q1 Q2 Q3 Q4	Year 5 Q1 Q2 Q3 Q4
A - STAFF RECRUITMENT	12 mos →				
Identification:					
USAID Technician (Agro-Meteorologist)	3 mos →				
USAID Technician (Agronomist)	6 mos →				
USAID Technician (Agricultural Economist)	12mos →				
USAID Technician /a (Electronics-Trained)	6 mos →				
2 Research Officer Trainees (Agro-Meteorology)	3 mos →				
2 Research Officer Trainees (Agronomy)	6 mos →				
2 Research Officer Trainees (Agricultural Economist)	12 mos →				
2 Laboratory Technician Trainees (Electronics)	3 mos →				
1 Supervisory Officer	6 mos →				
3 Field Officers	6 mos →				

ACTIVITY	Year 1 Q1 Q2 Q3 Q4	Year 2 Q1 Q2 Q3 Q4	Year 3 Q1 Q2 Q3 Q4	Year 4 Q1 Q2 Q3 Q4	Year 5 Q1 Q2 Q3 Q4
B - <u>STAFF DEVELOPMENT</u>					
In U.S. For Training and Field Experience:	====	27 mos ====>			
USAID Technician - Davis (Agro-Meteorologist)	3 mos →				
2 Research Officer Trainees - Davis (Agro-Meteorologist)	——	27 mos →			
USAID Technician (Agronomist)	3 mos →				
2 Research Officer Trainees (Agronomist)	——	24 mos →			
2 Research Officer Trainees (Electronics)	6 mos →				
2 Research Officer Trainees (Agricultural Economics)	——	24 mos →			
On-The-Job Experience and Dissertation Research for Trainee Counterparts:			27 mos ====	====>	
2 Agro-Meteorologists			15 mos ——	→	
2 Agronomists			12 mos ——	→	
2 Agricultural Economists			12 mos ——	→	

ACTIVITY	Year 1 (Q1 Q2 Q3 Q4)	Year 2 (Q1 Q2 Q3 Q4)	Year 3 (Q1 Q2 Q3 Q4)	Year 4 (Q1 Q2 Q3 Q4)	Year 5 (Q1 Q2 Q3 Q4)
Transition to Full Responsibility by Counterparts:				9 mos →	
1 Agro-Meteorologist				9 mos →	
1 Agronomist				6 mos →	
1 Agricultural Economist				6 mos →	
1 Electrician	3 mos →				
C - <u>CROPPING SYSTEM PREDICTION CAPABILITY</u>					
EXPERIMENT CYCLE I (maize)	——————	15 mos →			
Crop Forecast (maize)			——————	Continuous	——————
Data outputs: (a) Plant or store soil moisture (b) Planting time (c) Variety choice (maize) (d) Plant population					
EXPERIMENT CYCLE II (sorghum)		——————	→		
Crop Forecast (maize, sorghum)				——————	——————
Data outputs: Congruent categories (a) thru. (d) for sorghum plus (e) crop choice between (maize, sorghum)					

ACTIVITY	Year 1 Q1	Year 1 Q2	Year 1 Q3	Year 1 Q4	Year 2 Q1	Year 2 Q2	Year 2 Q3	Year 2 Q4	Year 3 Q1	Year 3 Q2	Year 3 Q3	Year 3 Q4	Year 4 Q1	Year 4 Q2	Year 4 Q3	Year 4 Q4	Year 5 Q1	Year 5 Q2	Year 5 Q3	Year 5 Q4
EXPERIMENT CYCLE III (food legume) /b																				
Crop Forecast (maize, sorghum, food legume)																				
Data Outputs:																				
Congruent categories (a) thru (e) for food legume plus (f) crop choice among (maize, sorghum, legume)																				
EXPERIMENT CYCLE IV (mixed cropping) /c																				
Crop Forecast /d (maize, sorghum, legume)																				
Data Outputs:																				
Congruent categories (a) thru (f) for mixed cropping plus (g) rudimentary cropping system																				
D - CONSULTANTS																				
Identification:																				
Agrometeorologist		(1)*				(1)*					(2)*				(4)*					
Agronomist											(2)*				(5)*					
Agricultural Economist											(3)*				(5)*					
Computer Programmer															(4)*					
E - DURATION OF USAID PROJECT SUPPORT /e																				

/a It is of critical importance to the project that USAID Technician (Electronics) be fully trained with experience in field installation, operation and service of neutron soil depth moisture gauges and scalars.

/b Choice of legume varieties adds the dimension of nutrition to the cropping system. Therefore, it is anticipated that some further study and consultation with representatives of the Partner States and a qualified agronomist will be required before a specific food legume crop and varieties are chosen.

/c The mixed cropping choice will be in conformity with data outputs from experiment cycles I, II and III and presently accepted mixed cropping practices in East Africa. The experimental data will facilitate crop selection based upon complementaries in relative growth responses to moisture deficits occurring within the growing season.

/d Crop Forecast and Data Outputs from Experiment Cycle IV which results in a rudimentary cropping system will be available at the end of year five. At this point in the project it is expected that full responsibility for its application and for the maintanance and further refinement in cycles which follow will rest with the EAAFRO staff assigned to this project.

/e Given the variance in starting dates among the three USAID Technicians, it is expected that the 48 months tours of at least two of these people (agronomist, agricultural economist) will carry them 6 months into what is designated as year five of the activity schedule. This should give assurance that all outputs are realized and that the transition to EAAFRO personnel is successfully effectuated. In addition, they would be available for participation in a review and evaluation with consultants identified in subsection D of this table, of the rather unique methodology which is expected to evolve as a product of this problems focused research effort.

*(1) Consultant, pre-installation planning, and refinement of experimental procedures in the field.

*(2) Consultants, analysis of first cycle data and planning legume crop cycle.

*(3) Consultant, development of forecast capability.

*(4) Computer modeling of rudimentary cropping system, if appropriate.

*(5) Consultants, refinement of cropping system and forecasting capabilities.

3. Predicted impacts

a) An impact upon National Research programs. The subproject will provide a model of appropriate research inputs necessary for more rational development of marginal rainfall areas. This impact is consistent with EAAFRO's role in East Africa and should help maintain their reputation with international agencies and member national governments. Indirectly, consistent leadership in research will help EAAFRO overcome some of its problems in recruiting staff officers.

The subproject is designed to integrate research outputs that require a problem solving focus and a multidisciplinary input. Such models of research are valuable in areas planning extensive development programs.

b) An impact upon agriculture in marginal rainfall areas. Development of cropping systems based upon soil moisture and climate and upon plant response to moisture regimes should stabilize production in these areas. Stability in these areas should make life more satisfactory by reducing anxiety and lead to more orderly community developments.

c) Increased production in the areas of marginal rainfall should result as managers respond to data inputs of increased reliability. As managerial decisions become more rational, managers can become more sophisticated. Other improvements such as improved varieties and tillage practices that will be emphasized by the subproject will also have an impact on increased production. The increased productivity of these areas should lead to increased monetary resources for within country development.

c) An impact on agricultural planning. Data from the subproject will provide a basis for monitoring production in marginal rainfall areas. Such monitoring and forecasting of production provides a basis for planning for such services as research, extension, transportation, marketing, price stabilization, credit, quality monitoring, fertilizer purchases, and famine relief.

d) An impact upon increased research capability. As a result of the personnel development aspects of the project new persons will be added to the staff of EAAFRO and will by their training, experience and interest increase staff capability to conduct projects in this area of science. The installation of new and expanded facilities will also expand research possibilities.

III. REQUIRED INPUTS FOR THE SUBPROJECT

The personnel and material inputs essential to the success of the subproject are enumerated in Table 4 for all agencies involved.

TABLE 4

TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR SUBPROJECT ON MARGINAL RAINFALL RESEARCH

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Others	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Personnel										
(1) USAID Technician (Agro-meterologist)	50,000	50,000	50,000	50,000	200,000			X		
(1) USAID Technician (Agronomist)	50,000	50,000	50,000	50,000	200,000			X		
(1) USAID Technician (Agricultural Economist)	50,000	50,000	50,000	50,000	200,000			X		
(1) USAID Technician (Electronics)	40,000	40,000			80,000			X		
(2) Research Officer Trainees (Agrometeorology)	6,200	6,200	10,280	10,280		32,960	X			
(2) Research Officer Trainees (Agronomy)	6,200	6,200	10,280	10,280		32,960	X			
(2) Research Officer Trainees (Agricultural Economics)	6,200	6,200	10,280	10,280		32,960	X			
(2) Laboratory Technician Trainees (Electronics)	4,800	4,800	7,900	7,900		25,400	X			
(1) Supervisory Officer	6,000	6,000	6,000	6,000		24,000	X			
(3) Field Officers	15,450	15,450	15,450	15,450		61,800	X			
Consultants	14,000	14,000	42,000	56,000	112,000			X		

TABLE 4 (Contd.)

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Others	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Participant Training										
(2) Research Officer Trainees in US.(Agrometerology)	20,700	18,000			38,700			X		
(2) Research Officer Trainees in US.(Agronomy)	20,700	18,000			38,700			X		
(2) Research Officer Trainees in US.(Agricult.Economics)	20,700	18,000			38,700			X		
(2) Laboratory Technician Trainees in US.(Electronics)	20,700	18,000			38,700			X		
Commodities										
(3) Land Rovers @ $7,900	23,700				23,700			X		
(4) Neutron Soil Depth Moisture gauges, scalers @ $4,000	16,000				16,000			X		
Access tubing 2" aluminium b/	5,000				5,000			X		
(1) Large Lysimeter	2,500				2,500			X		
(8) New Class A Evaporation Pans	2,000				2,000			X		
Irrigation System a/										
(3) Bore holes										
1-Muguga	8,000					8,000	X			
2-Major National Facilities	8,000					8,000	X			
(1) Large Irrigation Pump & Motor	10,000				10,000			X		
(2) Irrigation Pump & Motors	12,000				12,000			X		
Pan stock (500 ft of 8")	2,500				2,500			X		
Main line pipe(1500 ft of 8")	6,000				6,000			X		
Perforated pipe (1500 ft 6")	2,500				2,500			X		

TABLE 4 (Contd.)

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Others	EAAFRO	AID	Partner State	Other
	$	$	$	$	$	$				
Land and Structures c/										
Land - Muguga 2 hectares (5 acres)	1,000	1,000	1,000	1,000		4,000	X			
Land - Major National facilities 2 sites each 0.6 hectares (1.15 acres)	600	600	600	600		2.400			X	
Land - National facilities 4 sites each 0.36 hectares (0.9 acres)	720	720	720	720		2,880			X	
Construction of 10 Class A Evaporation Pans	2,500					2,500	X			
Travel and Per Diem										
Outside East Africa	5,700	5,700	5,700	5,700		22,800	X			
Within East Africa d/	12,000	12,000	12,000	12,000	32,000	16,000	X	X		
Consumable Supplies	2,000	2,000	2,000	2,000		8,000	X			
TOTAL FOR PROJECT					1,061,000	284,660				

a/ Estimates on irrigation equipment, especially boreholes and pipe costs, are site specific and highly variable. It is suggested that on site estimates be conducted, prior to submission of Food Crops proposal with Dr. Wang'ati.

b/ In the first year 3,200 ft. of 2" aluminium pipe will be used for access tubing, 1,000 ft. per year will be required in each of the following years.

c/ Land values are the approximate annual rental values for equivalent land in the vicinity of the experiment plus an increment of $ 100 per season for contributed labor and facilities not itemized in this table.

V. CONCLUSIONS AND RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

Population pressures are forcing unprecedented numbers of people to live in areas where the production of annual food crops is severely limited by lack of available moisture. Estimate of population growth in these areas ranges between 3.1 percent per year to a rate as high as 10 percent. Hard estimates of the land areas involved are not readily available. The magnitude of the problem can be estimated by assuming that the area is that which lies in the 20-30 inch rainfall area. In this area of Kenya about 2,000 square kilometers are being considered for irrigation development projects and 30,000 square kilometers are considered "medium potential" land where production is limited by lack of available moisture.

TABLE 5 Land area receiving 20-30 inches of rainfall 4 years out of 5 in East Africa in square kilometers.

	10-20 inch area	Total area
Kenya	70,000	538,000
Tanzania	312,000	945,600
Uganda	23,700	237,000

Tanzania has expressed an intention to develop 20,000 square kilometers in irrigation projects but the amount of land in marginal rainfall areas suitable for agricultural development does not seem to be determined. The intention to use these areas has has been dramatized by the decision to relocate the national capital to Dodoma in a marginal rainfall zone. Many of the resettlement villages (Ujamma villages) are located in marginal rainfall areas. The rainfall pattern tends to shift to a unimodal type in Tanzania and the definition of marginal rainfall areas will be somewhat different from that in Kenya. Not as much attention has been focused upon the Ugandan marginal rainfall area but population pressures there too are forcing development of these areas.

A major conclusion of the study is that large areas of land previously undeveloped because rainfall amounts severely limited crop production are now being opened to settlement because of population pressures on the land in the highly productive areas of East Africa. These developments are occurring at a high cost and bring on problems such as famine relief and soil erosion. Such problems impose a heavy burden on the society and become more difficult with the increasing scale of the problem.

B. RECOMMENDATIONS

The study team recommends that USAID support a research program at EAAFRO specifically designed to develop a data base for a more rational extension of agriculture into the marginal rainfall areas of East Africa.

A description of the research project recommended as summarized in Table 3 follows:

1. Basic research on growth characteristics of major food crops to quantify their influences on crop water requirements and on the actual water regime, and to quantify yield responses to water deficits in different growth periods.

2. Development of the capability to combine data on crop yield responses to water deficits with climatic and soil water measurements to predict the actual water regimes and the consequent crop yield expectations.

3. Serve as a center for data collection, computation and interpretation. This includes all available meterological and soils data, plus the research findings at all levels of this and related studies.

4. Serve in the role of coordinator of and liason between all research activities related to food crop production in the marginal rainfall areas by all agencies whether EAAFRO, international agencies, national Governments or universities.

5. Serve as an active disseminator of recommendations for field application of research findings by actively conveying useful information to national planners, research leaders in Partner States and personnel in agencies dealing with development in marginal rainfall areas such as UNDP-FAO, ICRISAT, IITA, World Bank, etc.

6. Serve as a computational and output center for annual cropping system recommendations based on soil water monitoring at key sites in marginal rainfall areas and on long range weather forecasting.

Inputs that are critical to this research program and should be supplied by USAID include:

1. Personnel:

   a) Agrometeorlogist - Team leader. A well qualified technician accomplished in research involving crop response to soil moisture and ability to coordinate persons from diverse disciplines.

   b) Agronomist - a technician with experience involving cropping systems in marginal rainfall environments.

   c) Agricultural economist - a technician with research experience in production economics and regional development applications in agriculture.

   d) Electronics equipment maintenance-man - a technician skilled in maintaining and repairing electronics equipment and specific experience with nuclear depth moisture gauges.

2. Training Functions

Develop expertise in indigenous counterpart personnel by providing opportunities for education in appropriate research specialities and active on-the-job training with accompanying transition to full responsibility in the research project.

3. Facility development

Specialized equipment required includes the installation of a functional lysimeter and irrigation facilities at Muguga and adequate irrigation capabilities at two National Research centers (at sites to be determined).

4. Commodities

Equipment including ten class A evaporation pans and four nuclear depth moisture gauges. An itemized list is provided in Table 4.

5. Travel

Because the project will be based in Muguga but will require weekly field measurements at six sites in Tanzania and Kenya some technicians will be required to live away from Muguga during the growing season and travel to other sites representative of the marginal rainfall area, travel expense becomes a major factor in support of this subproject.

6. The study team recommends an evaluation of the methodology of the subproject to ascertain the appropriateness of the research approach to resource development related problems.

The team found fragmentation in research approach at all levels which has contributed to development failures in marginal rainfall lands. For example, it is felt that an aggressive food legume program is necessary but will not be implemented without strong support from the marginal rainfall subproject. In a similar way almost all breeding activities in sorghum and millets have stopped in spite of the fact that they are the cereals most adapted to drought conditions. The extension of research findings into an integrated program that includes technical recommendations appropriately evaluated into the economic and social system mileau in which the farmer operates can be a major contribution and its progress should be monitored and viewed as it impacts marginal rainfall area agriculture.

APPENDIX A

JOB DESCRIPTION OF USAID AGROMETEOROLIGIST

TRAINING Ph.D. in Agrometeorology or Soil Science with emphasis on soil-water-plant relationships

EXPERIENCE At least 3 years experience in research involving crop growth and soil water monitoring. Experience in agrometeorology is desirable but not required.

DUTIES Direct the project including supervision of the design and instruction of the major research installations. The director will, in consultation with staff, design, conduct and analyze the experiments outlined in the subproject proposal. Other duties include effecting liason and cooperation with other units of EAAFRO, research and program planning agencies related to development of the marginal rainfall areas. Responsibility extends to initiating an evaluation of project activities with consultants and responsible authorities. The director shall be the chief educational officer of the project and will organize seminars and similar events to disseminate research findings to appropriate officials involved in marginal rainfall area agriculture. He will supervise the on-the-job training of counterpart technicians and their transition to full responsibility.

SALARY Commensurate with ability and experience.

JOB DESCRIPTION OF USAID AGRONOMIST

TRAINING	Ph.D.
EXPERIENCE	At least 2 years experience in designing, conducting and analyzing experiments under conditions of limited rainfall. Some extension experience would be useful.
DUTIES	Assist the director in his duties with particular responsibility for developing cropping systems appropriate to the marginal rainfall area. During the cropping season assume responsibility for supervision of experiments in Tanzania. Assist in the training of counterpart technicians and assist in orderly transition of their duties to full responsibility.
SALARY	Commensurate with ability and responsibility.

JOB DESCRIPTION OF USAID AGRICULTURAL ECONOMIST

TRAINING Ph.D. in Agricultural Economics or Economics with research specialization in resource economics and area development.

EXPERIENCE At least 3 years experience in research involving relationship between the agricultural sector and regional economic development. Experience with agricultural applications of linear programming and inter-industry analysis would be highly useful. Experience in extension would be helpful.

DUTIES Provide leadership in applications of agricultural economics as part of a multidisciplinary team whose objective is to develop an agronomic based cropping systems prediction capability for marginal rainfall areas. Primary concern will focus on identifying the economic implications of alternative systems, and to assess potential economic constraints and strategies which could be used in their operationalization. Duties also include training of Research Officer counterparts and facilitation of a transfer to full responsibility for Agricultural economic input in continuation of cropping systems studies.

SALARY Commensurate with experience and qualifications; competitive.

JOB DESCRIPTION OF USAID ELECTRONICS MAINTENANCE TECHNICIAN

EDUCATION	Beyond High School and certificate of satisfactory completion of electronics maintenance and repair course from technical or vocational school.
EXPERIENCE	Recent experience indicating competence in the use, maintenance and repair of neutron soil moisture depth gauges and scalars.
DUTIES	Assist in the installation of electronic equipment in the experimental sites so that it operates reliably and is reasonably accessable for maintenance. Assist in taking readings when appropriate and repair instruments that are broken or inoperative. Assist in the training of laboratory assistants in the use of electronic equipment. Duties also include the on-the-job training of a counterpart technician and in facilitating the orderly transfer of responsibility to the counterpart.
SALARY	Commensurate with ability and experience.

STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT C - SUGARCANE RESEARCH

I. BACKGROUND

A. PAST

Discussions on the need for a sugarcane variety development program were started as early as 1963 by EAAFRO. The major goal of the proposed project was to improve sugar production by breeding clones suited to East African environments that were resistant to the more important diseases, particularly smut and mosaic. It was not until 1966 that breeding work was initiated and the first crosses were made at Mtwapa, Kenya by Mr. B. de L. Innis in 1967. Prior to this time about 150 varieties were imported from various countries. Among these were C0421, NC0310 and NC0376 which continue to be the major varieties in the area. During and after this time sites were selected for National Research Centers at Kibos, Kenya, Efakara, Tanzania and Kituza, Uganda. A Disease Testing Unit as part of the EAAFRO Sugarcane Breeding Division was established at Kawanda, Uganda in 1969. The EAAFRO Sugarcane Breeding Division was established temporarily at Mtwapa, Kenya in 1966 but was moved to permanent headquarters in Kibaha, Tanzania in 1972. New facilities including office-laboratory building, housing for staff, implement shed, and crossing shelter were completed in 1971. A photoperiod house for inducing and synchronizing flowering and space for juice extraction equipment (Jeffco Cutter-Grinder) are currently under construction at the same site.

There is no other long term research on sugarcane by EAAFRO or the Partner States. Some Sugar Estates are doing elementary agronomic, entomological, and soils research (particularly salinity problems).

Partner States have been following a policy aimed at self-sufficiency in sugar. For example, in Kenya, production increased rapidly during the early 1970's but consumption increased even faster. In 1974, consumption was approximately 240,000 metric tons while production was only 160,000 metric tons. Therefore 80,000 metric tons were imported at high cost which placed heavy demands on foreign exchange. The situation in Tanzania was similar. Consumption was about 160,000 metric tons while production was 115,000 metric tons leaving a deficit of 45,000 metric tons which was imported from foreign sources. Foreign exchange problems were even more serious in Tanzania than in Kenya. Information on sugar consumption and production was not available from Uganda, but reports indicate production has decreased significantly in recent years.

In both Kenya and Tanzania strong effort is being made to expand existing factories to the limit of their capacities and to establish new sugarcane production areas with accompanying sugar factories. (Five in Kenya and three in Tanzania.)

Government officials hope that production can be increased faster than consumption and that self-sufficiency can be attained by the period 1978-81. Consumption will probably be in excess of 400,000 metric tons in Kenya and approximately 270,000 metric tons in Tanzania by 1980. Current figures were not available for Uganda.

There is urgent need to increase the sugarcane research program to support the existing and expanding sugarcane industry.

B. PRESENT SITUATION

1. Success to Date

The present status of the variety development program conducted by EEFRO in cooperation with National Research Centers is shown in Table 1. Personal observations and available data indicate one or two improved varieties will probably be available within 3 or 4 years. The EA.69 series is ready for final testing in the Balanced Lattice Trial at some Estates and National Research Centers. Research on other aspects of sugarcane production has not been initiated by EAAFRO or the National Research Centers. Some Sugar Estates are doing elementary research on salinity, entomological problems, cultural practices, and weed control.

2. Constraints

a) Inadequate number of trained personnel to carry out a broad based program on variety development, particularly an Agronomist to provide leadership in advanced selection and variety testing in cooperation with National Research Centers and Estates.

b) No trained personnel to conduct research on salinity, compaction, percolation and fertilizer requirements.

c) Permanent headquarters for the Sugar Cane Breeding Division of EAAFRO, Kibaha, Tanzania became operational only in 1972.

d) The National Research Center at Efakara, Tanzania has not yet assigned a Research Officer to sugarcane. Consequently two EA series of seedlings were lost which has created a gap in the program.

e) Inadequate irrigation facilities at the Kibaha Station has limited expansion of the program. Only one pumping unit is available. This unit was out of operation for at least 5 weeks during early 1975. Sugarcane breeding plots suffered serious drought stress and it is likely that many varieties will not flower. This will seriously curtail the 1975 crossing program.

f) There may be some difficulty in obtaining and keeping expatriates at Kibaha because of its isolation, particularly if school age children are involved.

TABLE 3

EAAFRO AND NATIONAL RESEARCH CENTER
SUGARCANE RESEARCH PERSONNEL

I. SUGAR BREEDING DIVISION - EAAFRO

(1) Kibaha, Tanzania

(i) Principal Research Officer (Breeder) - J.N.R. Kasembe (B.Sc. Ph.D)
(Also Head of Administration)
(ii) Principal Research Officer (Agronomist) - I.S. Mkwara (Dip.Agric).
(iii) Research Officer 'Trainee' - F.E. Mbema (B.Sc.)

Supporting Staff

(i) Scientific Assistant (Breeding)
(ii) " " (Agronomy) vacant
(iii) " " (Pathology) "
(iv) " " (Chemistry) "
(v) Laboratory Assistants 4 positions

(2) Kawanda, Uganda - EAAFRO Disease Testing Unit

(i) Research Officer (Pathologist) - M.Sumbuwa-Bunnya (B.Sc., M.Sc.)

Supporting Staff

(i) Scientific Assistant (Pathology)
(ii) Laboratory Assistant

II. NATIONAL RESEARCH CENTERS

(1) Kibos, Kenya

(i) Agricultural Officer (Sugar Officer) - S. Obura (B.Sc., M.Sc.)
(ii) " " (Sugar Officer, Coast) - A. Abubakar (B.Sc.)
(iii) Technical Officer (Cane Breeding) - W. Oguna (Dip. Agric).
(iv) Pathologist - Mr. Bungey (B.Sc.) (part time sugarcane)
(v) Chemist (B.Sc.) (sugarcane)
(vi) Entomologist - (vacant)

(2) Ifakara, Tanzania

(i) Agricultural Officer (Sugar Research) - vacant) To be filled
(ii) Assistant Field Officer I ") by
(iii) " " " II ") April 1, 1975

(3) Kituza, Uganda

(i) Agricultural Officer (Sugar Research) Mr. Opio
(ii) Laboratory Assistants (2)
(iii) Entomologist - (vacant)

g) The Sugarcane Pathologist located at Kawanda, Uganda has been able to travel to Kenya and Tanzania only occasionally. It is important that he be available on call.

3. Other Agencies and Donors Involved and Their Attitude Toward USAID Participation

a) National Research Centers operated by the Ministries of Agriculture in the Partner States are intimately involved with seedling selection and testing. These agencies would be less involved in the soil and water research. There are no other donor agencies involved with sugarcane research. The Ministries of Agriculture in Kenya and Tanzania welcome the participation of USAID.

4 & 5. Relationship between EAAFRO and National Research Past and Present

EAAFRO will provide the leadership for research in sugarcane at the request of the Ministries of Agriculture of the Partner States. Research on variety development is the only sugarcane research initiated so far. Crosses are made at the EAAFRO Station, Kibaha, Tanzania and the see distributed to National Research Centers at Kibos, Kenya, Ifakara, Tanzania and Kituza, Uganda. Seedling and advanced selection trials are grown at these Centers. Promising advanced selections are further selected and tested in cooperation with Sugar Estates. A description of a suggested variety development program is presented in Table 2. Research on soil and water problems will be conducted in cooperation with National Research Centers and Sugar Estates.

6. There are numerous sugarcane variety development programs throughout the world but EAAFRO has initiated the only such program in East Africa.

7. EAAFRO's Capabilities, Direction, and Viability in Carrying out the Subproject

a) EAAFRO was asked to conduct sugarcane research by Partner States of the East African Community.

b) Partner States have contributed funds to establish the Kibaha Station as evidence of their serious intent.

c) EAAFRO has a capable sugarcane breeder who is carrying out a variety development program within the limits of his time.

d) EAAFRO needs assistance, particularly an Agronomist to give direction to aovanced selection and final testing, and a Soil Scientist to conduct research on salinity, compaction and percolation.

e) Current and planned expansion of the industry provides evidence of the need for increase in sugarcane research.

TABLE 1

NUMBERS OF SEEDLINGS, INTERMEDIATE SELECTIONS, AND ADVANCED SELECTION AT NATIONAL RESEARCH CENTERS FROM 1967 TO 1975

Place	Series	Seedlings	Number in First Year Selections	Number in Second Yr. Selections	Randomized Block Trial	Latin Square	Balanced Lattice
Kibaha Tanzania	-	-	-	-	-	-	-
Kibos, Kenya 1/	EA 69	15,423	1,616	53	16	16	NYS 2/
Kituza, Uganda	EA 69	10,993	1,580	37	4	4	NYS 2/
Efakara, Tanzania	EA 69	994	135	9	9	4	NYS 2/
Kibaha, Tanzania	EA 70	-	-	-	-	-	-
Kibos, Kenya	EA 70	40,664	4,632	210	44	5	NYS 2/
Kituza Uganda	EA 70	39,046	2,645	101	30	IF 3/	-
Efakara, Tanzania	EA 70	-	-	-	-	-	-
Kibaha, Tanzania	EA 71	-	-	-	-	-	-
Kibos, Kenya	EA 71	73,965	7,000	555	48	16	NYS 2/
Kituza, Uganda	EA 71	3,663	633	IF 3/	-	-	-
Efakara, Tanzania	EA 71	3,000	196	32	6	IF 3/	-
Kibaha, Tanzania	EA 72	-	-	-	-	-	-
Kibos, Kenya	EA 72	-	-	-	-	-	-
Kituza, Uganda	EA 72	17,040	1,912	IF 3/	-	-	-
Efakara, Tanzania	EA 72	-	-	-	-	-	-

Table 1 (continued)

Place	Series	Seedlings	Number in First Year Selections	Number in Second Yr. Selections	Randomized Block Trial	Latin Square	Balanced Lattice
Kibaha, Tanzania	EA 73	20,000	NYS 2/	-	-	-	-
Kibos, Kenya	EA 73	14,593	1,147	316	21	NYS 2/	-
Kituza, Uganda	EA 73	3,752	NYS 2/	-	-	-	-
Efakara, Tanzania	EA 73	-	-	-	-	-	-
Kibaha, Tanzania	EA 74	1,500	NYS 2/	-	-	-	-
Kibos Kenya	EA 74	26,663	236	NYS 2/	-	-	-
Kituza Uganda	EA 74	20,000	NYS 2/	-	-	-	-
Efakara Tanzania	EA 74	1,500	NYS 2/	-	-	-	-

NOTE:

1/ Some of the seedlings and selections shown were grown at Mtwapa.

2/ NYS means not yet selected

3/ IF means in the field and may be selected if condition of plants will permit. It is possible that this material will (or has been) lost.

TABLE 2 DESCRIPTION OF SUGGESTED EAAFRO SUGARCANE VARIETY DEVELOPMENT PROGRAM

The following steps in the variety development program would all occur during a given year after the program was fully operational. For example crosses would be made during the same year as testing of an EA series in the plant crop of the Latin Square Trial while a year earlier EA series would be tested in the first ratoon crop of the Latin Square Trial (e.g. EA 78 series in plant crop, EA 77 series in first ratoon crop). The program as presently operated is at the equivalent of Year 7.

YEAR 0 Crossing - 75-200 biparental crosses made at Kibaha, Tanzania.

YEAR 1 Seedlings - 20,000 each year at each National Research Center Ifakara, Tanzania; Kibos, Kenya; and Kituza, Uganda.

YEAR 2 First year selections - 2,000 at each National Research Center

YEAR 3 Second year selections - 200-250 at each National Research Center

YEAR 4 Randomized Block Trials (plant crop) 30-50 entries at each National Research Center.

YEAR 5 Randomized Block Trial (first ratoon 30-50 entries at each National Research Center.

Best 8-10 selections distributed from each originating National Research Center to the other National Research Centers and all Estates (12 in total) using the first ratoon crop as the seed source.

YEAR 6 Plant crop of Latin Square Trials with 8 to 10 entries at originating National Center, single 15 foot row at other National Research Centers and Estates.

YEAR 7 First ratoon crop of Latin Square at originating National Research Center, Plant Crop of Randomized Block Trial with 16-30 entries at other National Research Centers and Estates. Multiply seed of best 15 varieties in 5 row plots 15 feet long using Randomized Block Trial as seed source.

YEAR 8 Plant crop of Balanced Lattice Trial at originating National Research Center, first ratoon crop of Randomized Block Trial at other National Research Centers and Estates.

YEAR 9 First ratoon crop of Balanced Lattice Trial at originating National Research Center, Plant Crop of Latin Square Trials at other National Research Centers and Estates. Estates should make initial planting of promising varieties.

YEAR 10 Second ratoon crop of Balanced Lattice Trial at originating National Research Center, first ratoon crop of Latin Square Trial at other National Research Centers and Estates. Estates should be encouraged to further increase promising varieties. Best varieties can be formally released at this time or after harvest of plant, first or second ratoon crop of Balanced Lattice Trial at other National Research Centers and Estates.

YEAR 11 Plant crop of Balanced Lattice Trial at other National Research Centers and Estates.

YEAR 12 First ratoon crop of Balanced Lattice Trial at other National Research Centers and Estates.

YEAR 13 Second ratoon crop of Balanced Lattice Trial at other National Research Centers and Estates.

contd.../7

Table 2 (continued)

PLOT SIZES AND REPLICATIONS

Seedlings:	Space planted at 2.5 foot intervals in rows 5 feet apart.
First Year Selections:	Plant one stalk (± 5 feet long) with 3 foot ally between plots.
Second Year Selections:	Two-row plots 15 feet long.
Randomized Blocks Trial:	Three-row plots 15 feet long with two replications
Seed Multiplication:	Five-row plot 15 feet long of 15 best clones in the plant crop of the Randomized Block Trial.
Latin Square Trial:	Four-row plots 30 feet long with 8-10 entries (replications)
Balanced Lattice Trial:	Six-row plots 36 feet long with 4 replications. Harvest 4 center rows.

DATA

Seedlings:	Visual observations on tillering, stalk diameter, stalk length, erectness, freedom from diseases.
First Year Selections:	Visual observations on stalk length, stalk diameter, erectness and freedom from diseases, stalk counts and hand refractometer brix of promising selections. Permanent EA number assigned to varieties advanced to second year.
Second Year Selections:	Visual observations on freedom from diseases and erectness. Stalk counts, 10 stalk sample to determine average stalk weight and extract juice for brix and pol (sucrose) determination. Estimated tons cane per acre as product of stalk weight time stalk number.
Randomized Block Trial:	Observation on freedom from disease, weigh plots to determine cane yield, juice analysis to determine brix and pol (sucrose) apply factory recovery factor to determine recoverable sugar per acre, fibre percent determination. Best selections will be tested for resistance to smut, mosaic virus, and leaf scald by the Sugarcane Pathologist.
Latin Square Trial:	Same data as in Randomized Block Trial
Balanced Lattice Trial:	Same.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1. Subproject Objectives

a) Provide high yielding, disease resistant, drought tolerant, sugarcane varieties.

b) Improve Kibaha station by supplying supplemental irrigation to ensure adequate plant growth and flowering so that its major function of providing true seed from crosses can be accomplished even in years with low rainfall.

c) Distribute the best 8 or 10 advanced selections from each originating National Research Center to the other National Research Centers and Sugar Estates (12 in total) to increase the probability of obtaining improved varieties for the different microclimates.

d) Provide information to Sugar Estates on salinity, compaction, and percolation problems.

e) Provide Sugar Estates with better cultural practices and management schemes.

f) Provide a soil testing service for Sugar Estates and outgrowers.

g) Train Research Officer candidates to replace the USAID Agronomist and Soil Scientist.

2. Technical Feasibility of the Subproject

a) The Kibaha station is operational to a substantial degree. With adequate irrigation, the climatic conditions are favorable for flowering of sugarcane and therefore the primary function of crossing can be successfully accomplished. Laboratory space is available for soil and water research.

b) National Research Centers have been established where seedlings and subsequent selections can be grown.

c) At least several of the Sugar Estates are anxious to cooperate with EAAFRO and National Research Centers personnel in conducting research trials. Many Estates have Agronomists to assist with the research work.

d) There is a nucleus of trained EAAFRO and National Center professional and support staff who can carry out a successful program if assistance is provided.

3. Beginning and Ending Point with Intermediate Targets for USAID Assistance

The beginning of USAID assistance should be immediately with purchase of all equipment for the Kibaha Station and recruitment of the

USAID Agronomist and Soil Scientist. The Agronomist can begin the key part of his work immediately since there is an ongoing program and additional equipment is not essential for him to initiate his work.

By the time all soil and water research equipment is operational the Soil Scientist will have surveyed the East African sugar industry, identified major problems as to location and type and formulated specific research plans. By the end of year one the Soil Scientist Research Officer Trainee should be in training, Agronomist Research Officer Trainee recruited and observation period essentially complete in preparation for training, Agronomic research well under way, part of the soil and water research initiated.

By the end of year 2, the training of the Soil Scientist Trainee should be nearing completion, training of Agronomist Trainee begun, the Soils Testing Laboratory operational, and salinity, compaction, and percolation research yielding useful data. Several Randomized Block Trials should have been installed at various Estates.

By the end of year 3, the Soil Scientist Trainee should have completed training in the U.S. and be working under the direction of the USAID Soil Scientist. Training of the Agronomist trainee should be near completion. The Soils Testing Laboratory should be fully operational and supplying fertilizer recommendations to Estates and outgrowers. Some assistance and advise should be provided to Estates on salinity, compaction and percolation proglems. Data on the plant crop of the Randomized Block Trials should have been collected at several Estates and National Centers. Varieties that are in Latin Square Trials in 1975 should be ready to release and recommend for commercial production in areas where they will have been tested.

By the end of year 4, the Soil Scientist trainee should be in command of the ongoing soil and water research program and the USAID Soil Scientist prepared to leave. The Agronomist Trainee should have completed training and be working under the direction of the USAID Agronomist. It may be necessary for the USAID Agronomist to remain an additional 6 months to one year before the Agronomist trainee is ready to assume full command of the agronomic research program.

4. <u>Importance of Subproject to the Development of Food Crops in East Africa</u>

a) Sugar is considered a basic food commodity in most countries of the world. Kenya and Tanzania had a combined sugar deficit of 120,000 metric tons in 1974. Additional sugar production will be obtained with higher yielding varieties, correct fertilizer recommendations, and advise on salinity, compaction and percolation problems. A 10 to 20% increase in sugar production from the subproject research areas within 10 years can be expected.

B. EXPECTED OUTPUTS

1. Basic Assumptions for the Success of the Project Are

a) That the East African Community will continue to support the sugarcane research program.

b) That the Kibaha Station will be a viable research unit capable of providing the true seed from crosses for the variety development program and the support for soil and water research.

c) That a trained East African staff will be available to carry on the research after USAID withdraws assistance to these projects.

2. Predicted Benchmarks of Achievements

a) Release for commercial production within 3 or 4 years one or two varieties that are currently (1975) ready for final testing. The varieties have not been tested in all sugar producing areas of East Africa but they will be adapted to at least some of the areas where tested.

b) Begin testing advanced selections at all Sugar Estates within one year.

c) Research on salinity, compaction and percolation problems well under way in one year.

d) Provide soil testing service to Sugar Estates within 2 years.

e) Begin training of counterpart Soil Scientist within one year.

f) Recruit and begin training of Counterpart Agronomist within 12 to 18 months.

g) Complete USAID assistance to soils and water research within 4 years.

h) Complete USAID assistance to this phase of Agronomy (variety development) within 4 to 5 years.

3. Predicted Impact

a) EA varieties will be grown commercially, at least on a limited scale within 5 or 6 years and additional varieties will be developed in EAAFRO and grown by Sugar Estates and outgrowers within 10 years. These high yielding varieties will help reduce the sugar deficit in East Africa. An increase in production of 5 to 15 percent from improved varieties can be expected within 10 years.

b) The services of the soil testing laboratory will be used by Sugar Estates to obtain information on more efficient use of fertilizer and thereby reduce costs and improve yields by 3 to 5 percent.

c) Research on salinity problems will assist Sugar Estates in managing problem areas now in production and provide information on other areas that are suitable for sugar production.

d) EAAFRO will become capable of conducting its own variety development program and soil and water research.

III. REQUIRED INPUTS FOR SUBPROJECT

A. EAAFRO CONTRIBUTION

1. Personnel to Support USAID Positions

a) Agronomist Research Officer Trainee (B.Sc.)
b) Soil Scientist Research Officer Trainee (B.Sc.)
c) Two scientific assistants (Diploma)
d) Three laboratory assistants (School Certificate)
e) Two drivers (vehicle)
f) One driver (tractor)
g) Secretary
h) Existing EAAFRO and National personnel are shown in Table 3.

2. Capital Inputs

a) Office-laboratory space (Two small offices and one large laboratory)
b) Housing for staff (one Class A and one Class B, i.e. 3 and 2 bedroom)
c) Tractor and farm implements
d) Suitable transportation (two station wagons)
e) Truck for hauling cane samples
f) Forty acres of irrigated land at Kibaha Station

3. Financial Support

Recurrent operating expenses including salaries of EAAFRO staff, travel within East Africa.

4. Training

Identify two Research Officer Trainees (B.Sc.)

5. Commodities

Consumable supplies, such as laboratory chemicals, tags, twine, fertilizer, etc. For Agronomy, these are currently in use and require only increased amounts.

B. USAID CONTRIBUTION

1. Personnel

Research Agronomist (4 to 5 years suggested)
Research Soil Scientist (Chemist) (4 years suggested)

2. Commodities

a) Equipment to support Agronomist - see Table 4
b) Soils research laboratory equipment - see Table 5

3. Consultation Services

Up to 3 months each year for qualified U.S. consultant to support ongoing and suggested sugarcane research subproject.

4. Training

Provide two years training (from B.Sc. to M.Sc.) for each of the two Research Officer Trainees (one Agronomist and one Soil Scientist). Up to one month per year short term training for EAAFRO sugarcane scientists.

5. Time Phase for Inputs

All USAID input should be made immediately, except for training, consultation service and continuing salaries of USAID scientists. Training for Soil Scientist Research Officer Trainee would begin within 6 months and training for the Agronomist Research Officer Trainee would begin 6 months to one year after recruitment. Training would be for approximately 2 years as previously indicated. Consultation service would be provided as needed during the 4 to 5 years time period. See Table 6 for time phasing of financial input.

TABLE 4

EQUIPMENT LIST (AGRONOMY) - Kibaha, Tanzania

Irrigation equipment

100 hp electric motor		$.	7,500
HSRB-5 pump			7,000
piping, sprinklers, elbows, valves			9,500
Installation			1,000
Yearly service costs			500
	sub total		25,500
Electronic computer (Canon Model SE 600)			3,000
	TOTAL	$.	28,500

When USAID Agronomist comes on board this list may be altered or expanded.

TABLE 5 EQUIPMENT LIST (SOIL AND PLANT ANALYSIS) - Kibaha, Tanzania

1.	Kjeldahl Apparatus - digestion and distillation racks and heaters. 10 sample capacity with flasks and associated glasswate and exhaust systems	$ 4,500
2.	Colormeter, visible light with appropriate filters and accessories	2,400
3.	Flame photometer	3,000
4.	Grinding mills for plant samples	1,600
5.	Shakers and screens for soil preparation	500
6.	Soil augers and probes	500
7.	Top loading balance, 1 kg. capacity	1,800
8.	Scale, 10 kg. capacity	2,000
9.	Analytical balance	3,500
10.	PH meter and replacement electrodes	300
11.	Oven, drying	300
12.	Conductivity bridge	300
13.	Centrifuge	1,500
14.	Water deionizing equipment	300
15.	Refrigerator	300
16.	(2) Neutron moisture depth probes, scalers, and access tubing (TROXLER, North Carolina, U.S.A.)	8,000
17.	Glassware, volumetric flasks, pipettes, beakers, flasks etc.	1,500
18.	Reagents	3,000
19.	Burners and hot plates	400
20.	Suction plate	400
		$ 36,100

A Technico Auto Analyser ($25,000) would replace several items on the above list but the complexity and unavailability of services makes purchase of such a piece of equipment a substantial risk.

The above list may be altered when the USAID Soil Scientist comes on board.

TABLE 6

TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR REGIONAL SUGARCANE RESEARCH

Input	Time and Cost				Total by Category		Source			
	Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
	$	$	$	$	$					
Personnel										
(1) USAID technician (Agronomist)	50,000	50,000	50,000	50,000	200,000			X		
(1) USAID technician (Soil Scientist)	50,000	50,000	50,000	50,000	200,000			X		
Consultants	14,000	14,000	14,000	14,000	56,000			X		
(3) Laboratory Assistants	3,300	3,300	3,300	3,300		13,200	X			
(3) Drivers	3,050	3,050	3,050	3,050		12,200	X			
(1) Stenographer	1,500	1,500	1,500	1,500		6,000	X			
(3) Research Officers at National Stations	15,000	15,000	15,000	15,000		60,000			X	
(2) Research Officer Trainees	6,200	6,200	10,300	10,300		33,000	X			
(2) Scientific Assistants	4,800	4,800	4,800	4,800		19,200	X			
Casual Labor	7,150	7,150	7,150	7,150		28,600	X			
Participant Training										
(2) Research Officer Trainees (Agronomy)		20,700	19,200		39,900			X		
(2) Research Officer Trainees (Soils)	10,350	19,950	9,600		39,900			X		
Commodities										
Land Cruiser	15,700					15,700	X			
Deep Freeze	1,150					1,150	X			
Irrigation equipment	25,500				25,500			X		
Electronic computer	3,000				3,000			X		
Soils Laboratory equipment	36,100				36,100			X		

Table 6 (contd.)

Input		Time and Cost				Total by Category		Source			
		Year(1)	Year(2)	Year(3)	Year(4)	USAID	Other	EAAFRO	AID	Partner State	Other
Land and Structures	a/										
Kibaha Station (50 to 125 acres)	b/	5,000	7,500	10,000	12,500		35,000			X	
Government Station (Avg.135 acfes)	b/	27,000	27,000	27,000	27,000		108,000			X	
Sugar Estates (Avg.300 acres)		60,000	60,000	60,000	60,000		240,000				X
Travel and Per Diem											
Outside East Africa		5,700	5,700	5,700	5,700		22,800	X			
Within East Africa		2,285	2,285	2,285	2,285		9,140	X			
Consumable Supplies and Utilities	c/	22,000	22,000	22,000	22,000		88,000	X			
TOTAL FOR PROJECT						600,400	691,990				

a/ Land use at the Kibaha station is expected to increase from 50 acres in year one of the project to 125 acres in year four. Labor contribution for EAAFRO is included under Personnel category.

b/ The per acre value of land use includes an additional increment of $ 100 for additional labor and maintenance required by the experiment.

c/ This item includes maintenance of equipment and buildings and estates.

IV. CONCLUSIONS AND RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

An expanded sugarcane research program to support the existing and developing sugarcane industry in East Africa is essential if the Community is to achieve self-sufficiency in sugar production within the foreseeable future. All commercial varieties were developed in other countries, particularly India and South Africa. Greatly improved varieties can be developed for East Africa but EAAFRO requires assistance to develop and maintain an adequate variety program. There are serious salinity problems in several existing areas of the sugar industry and areas have been identified by the Partner States for sugar production that will magnify the scope of this problem. There is no long term research on salinity, compaction, or percolation problems in East Africa. One or two Sugar Estates are attempting to determine critical salinity limits but they need assistance from EAAFRA.

There is no research on sugarcane insect problems in East Africa. There are three insects that are causing economic loss at the present time. The most serious problem is white scale (Aulacaspis tegalensis) followed by stem borer (Eldana sp) and several species of white grub. EAAFRO will require assistance in the form of a qualified scientist in order to attack these problems.

The amount of work required by the USAID Agronomist on the variety development program will leave little time to conduct research on cultural practices and management schemes. Either USAID or other donor agency should seriously consider providing a second qualified Agronomist to concentrate on cultural practices and management schemes while an EAAFRO technician is trained to assume the responsibility.

Travel of the EAAFRO sugarcane pathologist stationed at Kawanda, Uganda has been restricted during the last few years. If this situation continues EAAFRO will require additional assistance to provide a competent sugarcane pathologist to monitor the disease problems in Kenya and Tanzania. It is likely that an expatriate will be needed to provide technical assistance while an East African is recruited and trained.

The team is in agreement that USAID should first provide an Agronomist whose principal duties will be on advanced selection and variety testing, and a Soil Scientist whose principal duties will be establishment and supervision of a soils testing laboratory and research on salinity, compaction, and percolation problems. There is a great need, however, for an Entomologist, a second Agronomist, and perhaps a Pathologist if travel of the present EAAFRO Pathologist continues to be restricted. Even with all of the above mentioned scientists, this represents a skeletal sugarcane research program compared to other progressive sugarcane producing areas. It would require a total 15 to 25 Ph.D.'s with supporting staff in such fields as Breeding, Agronomy, Pathology, Entomology, Biochemistry, Plant Physiology, Agricultural Engineering, Weed Control, and Soil and Water Research to provide adequate technical support for the expanding East African sugar industry. The proposed subproject will strengthen EAAFRO research in variety development and soil and water research and repay the expenditure many times over.

B. RECOMMENDATIONS

It is recommended that USAID support sugarcane research in East Africa by providing assistance to EAAFRO based on the following priority:

1. Supplemental irrigation equipment for the Kibaha Station.

2. Agronomist and supporting equipment stationed at Kibaha to concentrate on advanced selection and variety testing. Assistance needed for 4 to 5 years while an East African is trained to assume responsibility.

3. Soil Scientist and supporting equipment stationed at Kibaha to concentrate on establishment and supervision of soil testing laboratory and conduct research on salinity, compaction and percolation problems. Assistance needed for 4 years while East African is trained to assume responsibility.

4. Provide qualified consultants for up to 3 months each year on sugarcane problems as requested by Head of the Sugarcane Breeding Division or Director of EAAFRO.

5. Provided funds are available in 3 or 4 years, a Research Entomologist and supporting equipment stationed at Muguga to work on white scale, stem borer, and white grubs. Assistance needed for 4 to 6 years while East African is recruited and trained to assume responsibility.

6. Provided funds are available in 3 or 4 years, a second Agronomist and supporting equipment to concentrate on cultural practices and management schemes. Assistance needed for 4 to 6 years while East African is recruited and trained to assume responsibility.

7. If the current constraints continue for another year on travel of the EAAFRO Sugarcane Pathologist stationed at Kawanda, Uganda assistance will be needed in providing a sugarcane pathologist to monitor and research diseases in Kenya and Tanzania. (Priority 5).

JOB DESCRIPTION OF USAID SUGARCANE SOIL SCIENTIST (CHEMIST)

TRAINING:	Ph.D. in Soil Chemistry/Physics with adequate training to establish a soil testing laboratory aimed at recommending fertilizer requirements for sugarcane.
EXPERIENCE:	At least 5 years experience in research dealing with soil chemistry, soil physics, or soils testing. Experience in salinity problems would be desirable.
DUTIES:	Establish and supervise soils testing laboratory aimed at making fertilizer recommendations for sugarcane. Establish and supervise sugarcane juice analysis laboratory for determining fibre percentage, brix and pol of sugarcane samples from the variety development program. Conduct research on salinity, percolation, and compaction of problem soils. Advise sugarcane growers on water quality for irrigation and management schemes for problem soils. Cooperate with the Agronomist on fertility and cultural practices research

JOB DESCRIPTION OF USAID SUGARCANE AGRONOMIST

TRAINING: Ph.D. in crop breeding/agronomy with at least some training in pathology. A good understanding of experimental design related to variety testing and cultural practices is essential.

EXPERIENCE: At least 5 years experience in crop breeding and/or agronomic research related to variety testing and/or agronomic research (cultural practices). Some experience with sugarcane would be highly desirable. In lieu of sugarcane experience, the candidate should visit the USDA Sugarcane Research Stations at Canal Point, Florida and Houma, Louisiana, and the Experiment Station of the Hawaiian Sugar Planters Association for a two-week orientation period at each location.

DUTIES: Provide leadership in the advanced selection stages and replicated variety testing beginning at year 5 (Table 2). The Agronomist will be responsible for distributing the 8-10 best selections from the originating National Research Centers to other National Research Centers and all Estates (12 in total) in the Partner States of Kenya, Tanzania and Uganda. He will work with Estate Agronomists in carrying out the testing program from the 15 foot row through the Balanced Lattice Trial (Table 2). Analysis and interpretation of data will be his responsibility. The Agronomist must be able to recognize common sugarcane diseases and to test for reaction to smut (*Ustilago scintiminae*) if necessary. In addition, the Agronomist will conduce research on cultural practices and management schemes as time permits. This work should be conducted in cooperation with the Soil Scientist (Chemist).

REPORT OF STUDY TEAM FOR EAST AFRICAN FOOD CROPS RESEARCH PROJECT

618-110-10-657

SUBPROJECT D - PLANT QUARANTINE

I. BACKGROUND

A. INTRODUCTION

In response to the demands of a burgeoning population for more and better food, East Africa has greatly accelerated plant improvement programs. The volume of importation of all kinds of plant materials is increasing rapidly. The flow of new germ plasm is expected to increase as international organizations such as IITA and CIMMYT release materials for area-testing and multiplication. Associated with importation of plant materials is the hazard of introducing new insect pests and plant pathogens. Achieving maximum public benefit from imports requires expeditious inspection and release of plant materials to the farmer, breeders and other consumers. At the same time the procedure must be thorough enough to prevent or at least slow down the spread of plant diseases and insect pests. Such is the mission of the regional plant quarantine station.

B. PAST

The East African Plant Quarantine Station which as a part of the East African Agriculture and Forestry Research Organization (EAAFRO) provides post-entry plant quarantine services for the three Partner States (Kenya, Tanzania and Uganda) that comprise the East African Community. The EAPQS is the only plant quarantine facility in East Africa.

From 1931 to 1951 vegetatively propagated plant material of specified species which might be carrying diseases unknown in East Africa were quarantined at the East African Agricultural Research Station at Amani, within the then Tanganyika territory. In 1951 that station was closed down and the staff moved to Muguga in Kenya as the nucleus of the newly formed EAAFRO, and for a time there was no quarantine facility and no imports were permitted (e.g. sugarcane).

Realizing the need for a new quarantine station, the present site was selected and, under the leadership of H. H. Storey, the office/laboratory building and several small greenhouses were constructed. The Station opened in 1954 and from then until 1970 Dr. F. M. L. Sheffield, a British plant pathologist, was in charge. Since 1970 the Station has been under the direction of plant pathologists from the U.S.D.A. with funds provided by USAID.

C. PRESENT SITUATION

1. Success to Date

a) Large numbers of importations of plant material are processed through the Quarantine Station each year (400 in 1972). Many are allowed to come in under permit and are not detained at the Station. A list of plants that must be quarantined is presented in Table 1. While the time required to process material which is subject to actual quarantine varies considerably depending on growth rate and the tests required, it is understood that the rate of release has improved considerably in recent months.

b) Material which has come through quarantine (e.g. sugarcane) has proved to be remarkably clean.

c) Since 1970, the attitude of the Station has changed to one of assisting importation of material rather than one of preventing entrance.

d) There have been no official complaints from Partner States during the period following 1970.

e) Efforts are being made to improve communications between the EAPQS and potential recipient research institutions in the Partner States. The head of EAPQS has visited a number of research institutions with this in mind and has been able to bring about better understanding of the quarantine function. A bulletin in both English and Swhili which discusses the need for plant control, the dangers of introduced plant pests and the operation of EAPQS, is now being printed.

2. Constraints

a) Space limitations in glass houses for isolation and for propagation have been largely overcome by doubling the number of houses in 1973.

b) The high elevation and the lower than optimum temperatures that can be maintained in glass houses at the Station are not conducive to normal growth of certain of the more tropical plants, such as sugarcane. Under these unfavorable conditions some disease symptoms may not be expressed (an example is the Sugarcane Mosaic Virus in sugarcane) and growth is slow.

c) Facilities for increase of plant material released for distribution under quarantine are rather limited, therefore the quantity available is not enough to satisfy demands. It may not be a function of a Plant Quarantine Station to provide large quantities of materials to recipients, nevertheless there is demand for an organization to increase materials for distribution. Two additional propagation greenhouses are under construction at the Quarantine. Station, but it is unlikely that even these will satisfy the demand.

The East African Plant Quarantine Station (EAPQS) is located about 1^{o} south of the equator at an elevation of 6,800 ft. There are now 80 single unit glass houses, (10' x 6' x 13' high), 4 phytotrons and 2 propagation houses (80 x 15 ft). Construction of the first propagation house is almost complete, and a start made on the second. A new refrigerated seed storage unit is being constructed with funds from USAID. There are facilities for steam sterilization and storage of soil and laboratory space for seed pathology and tissue culture work.

There are 28 full time personnel. These consist of 2 Research Officers (USAID Plant Pathologist and EAAFRO Senior Horticulturist), 3 Scientific Assistants, 1 Clerk-Typist, 8 Laboratory Assistants and 14 Auxillary Staff.

Importations of plant materials into East Africa are governed by the regulations stipulated in the 8th non-legal draft of the Plant Protection (Importation) Order which was last revised in July, 1974. The East African Standing Technical Committee on Plant Imports and Exports (EASTCPIE) determines the plant quarantine policy and regulations of the East African Community. This Committee is made up of two representatives (usually the Senior Entomologist and Senior Plant Pathologist) from each of the Partner States, in addition to the Head and Senior Horticulturist of the EAPQS who act as Chairman and Secretary of the EASTCPIE, respectively. The plant quarantine regulations as indicated in the Plant Protection (Importation) Order can only be changed by unanimous consent of all the Committee members.

Depending on the risks involved to the agriculture in East Africa, the importation of plant material falls into the three broad categories:

(1) Imports which are prohibited because of the extreme risks involved, e.g. alternate hosts of certain rust fungi.

(2) Imports which must pass through quarantine because there is a risk of introducing a serious pest or pathogen. However, passage of the plant material through quarantine provides sufficient safeguard to allow detection of the pest or pathogen, if present, in or on the host plant, e.g. seeds of soybean, cuttings of sugarcane.

(3) Imports which can enter East Africa under permit because the plant material is imported from designated countries or areas where there is little or no risk of introducing new or serious diseases or pests, provided the exporter has met the requirements specified in a permit which is issued by the Ministries of Agriculture in the three Partner States, e.g. potato seed tubers from the U.K. and The Netherlands. Plant importation permits for all plant material that enters East Africa through the EAPQS are issued by the Head, EAPQS.

3. Other Agencies and Donors Involved and Their Attitude Toward USAID Participation

EAAFRO is the only agency involved in the Plant Quarantine Station. There are no other donors. ODA personnel connected with EAAFRO do give advice and assistance, particulary on virus problems.

4. Relationship Between EAAFRO and National Research Past and Present

a) The only plant quarantine service in East Africa is provided by EAAFRO at the request of the Ministries of Agriculture of the Partner States.

b) The Quarantine Station imports materials of several crops for national research programs. This is a vital function, particularly in variety development programs where centers of origin of germ plasm are outside East Africa (e.g. potatoes, cowpeas, pigeonpeas, etc.).

c) There have been some unofficial complaints that materials were not processed fast enough, but this situation has improved in recent months, particularly after visits by the Head of EAPQS to some of the research centers.

5. Views of Study Team Regarding EAAFRO's Capabilities, Direction, and Viability in Carrying out this Subproject

a) EAAFRO was asked to provide a plant quarantine service by Partner States of the East African Community.

b) Partner States have provided funds for establishment of facilities and for staff. As recently as 1973, funds were provided to double the glass house space. Two propagation houses are currently (1975) under construction. These investments by Partner States are evidence of concern for plant quarantine and and expression of confidence in EAAFRO's capability.

c) Except for a qualified Plant Pathologist, EAAFRO has a trained East African staff on board. The Senior Horticulturist now handles some administrative duties, and additional, could probably be delegated to him.

d) EAAFRO has critical need of the assistance of a highly qualified Plant Pathologist until an East African can be trained to assume the responsibility of pathologist and Head of the Division. The team believes the Quarantine Station will cease to perform its function unless USAID or another donor agency provides a highly qualified Plant Pathologist to act as Head until such time as a highly qualified East African assumes the responsibility.

e) The population increase in the East African Community (in excess of 3% per year) and the consequent increased demand for food has accelerated the demand for importation of plant material of many crops for testing and direct production, as well as for importation of germ plasm for use in research programs aimed at developing improved crop varieties adapted specifically to the need of the different areas of East Africa.

II. EXPECTED OUTPUTS

A. SUBPROJECT DESCRIPTION

1. Subproject Objectives

a) To import and provide to recipients, disease and pest-free plant materials that fall in the categories requiring quarantine for entry into East Africa.

b) To provide enough material to recipients so they can effectively increase the material for its intended use.

c) To provide plant quarantine information to people who may wish to import plant materials.

2. Technical Feasibility of the Subproject

a) The Plant Quarantine Station is fully operational. The glass house space was doubled in 1973. A trained East African staff, except for a Plant Pathologist, is on board and its primary function has been carried out with increasing effectiveness since 1954.

b) The main EAAFRO station, of which the Plant Quarantine Division is a part, is a thriving and progressive research institution under capable leadership.

c) The climatic conditions are satisfactory for all but a few tropical crops such as sugarcane (a suggestion for managing this crop appears in Section IV-A).

3. Beginning and Ending Points, with Intermediate Targets for USAID Assistance

In 1970 USAID began providing a Plant Pathologist who has served as Head of EAPQS. In addition some equipment has been provided. The tour of the present USAID Plant Pathologist will end in June of 1976. It is strongly urged that he be retained for a second tour to begin in July, 1976 and end June, 1978.

There is an East African in training at the University of Maryland who will be completing a Master of Science degree in virology in June, 1975. If it is decided that he should work toward responsibility in EAPQS, a desirable schedule for further training would be as follows: (See Table 2)

- On-the-job training at EAPQS, Muguga to June, 1976.
- Short term special training at US Plant Quarantine headquarters in Maryland, observations of sugarcane diseases in Louisiana, Hawaii and Austrailia. Special training at the Australian Plant Quarantine Service. Total of about 6 months, to January, 1977.
- Further on-the-job training for 18 months, to June, 1978, while USAID technician is still on post.

A second counterpart should be posted to the U.S. between June to September, 1975, for 2 years to a M.S. degree in virology (to mid 1977) and on-the-job training until June, 1978.

A review of progress should be made in June, 1977.

Complete USAID assistance of the subproject by June, 1978, when a fully qualified East African Plant Pathologist will be expected to assume the duties as Head of the Plant Quarantine Division of EAAFRO.

5. Importance of Subproject to the Development of Food Crops in East Africa

Excluding the entrance into East Africa of harmful, and perhaps devasting, diseases and other pests while permitting the entrance of plant materials that are essential to crop improvement, is a critical function if food production is to keep pace with demand. The increasing population in East Africa (3% per year) cannot be fed if destructive pests such as the cassava mite, which was introduced on cassava plants brought into East Africa illegally, are allowed to gain entrance. Cassava production is impossible in some areas of East Africa, particularly in parts of Uganda. Sugarcane smut is another serious pest which is thought to have been brought into East Africa on illegally imported cane. Other pests could be equally devastating if permitted to gain entry.

If the present Quarantine Station is kept strong the Partner States will support the station and probably no effort will be made to get separate quarantine stations - if separate quarantine stations are established then progress would be inhibited because there would not be a free passage of material from one country to another, thus greatly curtailing progress in breeding food crops as well as other crops.

B. EXPECTED OUTPUTS

1. Basic Assumptions for the Success of the Project

a) That the Partner States of the East African Community continue to support the Plant Quarantine Station.

b) That a trained junior and senior staff continues to be provided by EAAFRO.

c) That a highly qualified East African becomes available to assume the responsibility of Plant Pathologist and Head of the Division when USAID terminates its assistance.

2. Predicted Benchmarks of Achievement

a) Import and provide to recipients disease and insect-free plant material of those species that require quarantine for entry into East Africa (probably as many as 400 entries per year).

b) Breeders, Research Workers, Customs Officials and the Regional Plant Quarantine Staff will share a common concern for developing thorough regulations while permitting expeditious and efficient flow of imported plant materials. This will eliminate much potential friction.

c) Complete U.S. training and special training for counterparts by 1977 and final on-the-job training during final year of the present USAID technician.

d) The regional plant quarantine station will be under complete management of the trained East African Plant Pathologist. USAID assistance will be terminated by 1978.

3. Predicted Impact

a) Imported plant materials that require quarantine will have satisfied the continuing need of research agencies and other agricultural organizations of the Partner States of the East African Community.

b) The imported plant materials will serve directly as improved varieties in some cases and as the basic germ plasm for improvement of others. Together, these plant materials will be a major factor in increased food production in East Africa.

c) Numerous potentially destructive plant pathogens and insect pests that would have gained entry will have been intercepted. Thus the probability of increasing food production in East Africa will have been enhanced. Reductions in food production which might have resulted from the intercepted pests will have been prevented.

III. REQUIRED INPUTS FOR SUBPROJECT (See Table 3)

IV. CONCLUSIONS AND RECOMMENDATIONS FOR THE SUBPROJECT

A. CONCLUSIONS

The team considers the plant quarantine function vital to improvement of food crops in East Africa, and even to continued food production at a high level in the Partner States. Many diseases and insects pests have a wide host range and can be very destructive on several crops in addition to the one on which they gain entry to an area. Therefore, prevention of entry through an effective quarantine system is a very important part of EAAFRO's responsibilities. It is essential that the East African Community continue a quarantine program and that the program be as effective as possible in excluding harmful diseases and pests. In order to insure an effective quarantine program it is the opinion of the team that a highly qualified Plant Pathologist retain the position of Head of the Division. Should a poorly qualified pathologist head the organization or serve as Plant Pathologist the quarantine fuction is likely to become ineffective either through (1) inadequate screening and detection of pests or (2) recipients becoming thoroughly discouraged with the operation of the quarantine facility with accompanying increase in numbers of illegal entries, i.e. recipients may ignore the quarantine and bring in materials illegally.

The team also felt that the educational activities of the current USAID Plant Pathologist have been very helpful in creating an understanding and appreciation by recipients of the need for an effective quarantine. Continued travel throughout the community to explain the program is strongly urged.

It would strengthen the position of the quarantine service if custom officers were given some orientation on the importance of following plant quarantine regulations. Also, posters designed to create public awareness of the importance of plant quarantine should be posted in conspicious places in ports of entry.

Growth rate of sugarcane, at least, is not adequate for detection of some diseases (particularly Sugarcane Mosaic Virus) at the high altitude and low green-house temperatures that can be maintained at Muguga. Therefore a secondary open quarantine facility should be established at a lower elevation, isolated from sugar estates, where growth would be adequate. The primary quarantine should remain at Muguga where imported cuttings would be planted in greenhouses upon entry. After observation and disease testing, cuttings of apparently healthy plants should be transferred to the secondary open quarantine station, cuttings subjected to long hot water treatment and planted as soon after as possible. The quarantine pathologist should periodically inspect the plants after emergence for freedom from diseases, and at 8-10 months of age release plants which remain healthy for distribution by the EAAFRO Division of Sugarcane Breeding. Culture of plants in secondary quarantine would be the responsibility of the Division of Sugarcane Breeding.

The secondary quarantine stations could also be used for increase of crops originating from areas free of pest not present in East Africa. A phytosanitary certificate would be required.

Finally, the team concluded that the Plant Quarantine Division has done an outstanding job during the past several years and with the increased facilities now available along with qualified personnel this function will continue to be an essential part of EAAFRO's mission in protecting and improving agricultural production in East Africa.

B. <u>RECOMMENDATIONS</u>

1. It is recommended that USAID continue to assist EAAFRO Plant Quarantine Station by providing needed equipment and a qualified Plant Pathologist to serve as Head of the Division until Mr. Gathuru completes requirements for a M.S. in Plant Pathology, and pursues post M.S. training and on-the-job training under the USAID Plant Pathologist. These goals should be attained by June, 1978.

2. A second Plant Pathologist trainee should be sent to the U.S. just as soon as he can be identified by EAAFRO as a backup. Technical training should be provided for one to three scientific assistants for a period up to one year in such specialized fields as seed pathology, tissue culture, electron microscopy, serology or other techniques important to plant quarantine work.

3. Provide opportunity for USAID plant pathologist to attend at least one scientific meeting or seminar each year outside East Africa that deals with subject matter pertinent to plant quarantine such as virology, plant pathology, or application of specialized techniques.

4. That EAAFRO establish a secondary open quarantine for sugarcane as detailed in Section III-A. A suggested location is at Morogoro, Tanzania near the Faculty of Agriculture.

EQUIPMENT AND SUPPLIES WHICH ARE REQUIRED BY THE EAST AFRICAN PLANT QUARANTINE STATION, MUGUGA

(1) Incubator with temperature controls (0° to $50^\circ C$) and fluorescent lights. This unit will be used in our seed pathology studies.

Approximate cost: $1,500

(2) Mist propagation equipment for the new propagation house at the EAPQS. The equipment consist of a control unit, atomizer jets, solenoid valve, soil warming cables, thermostat, pressure pump and tank.

Approximate cost: $1,100

(3) One refrigerator for storing chemicals, agar media, fungus and bacterial cultures, etc.

Approximate cost: $ 500

(4) Miscellaneous glassware, chemicals agar media, etc. that cannot be purchased locally and which are needed for the tissue culture and seed pathology work at the Quarantine Station.

Approximate cost: $1,600

TOTAL $4,700

TABLE 1: LIST OF PLANT MATERIALS WHICH MUST PASS THROUGH THE EAST AFRICAN PLANT QUARANTINE STATION

Vegetative propagating material of dahlia, begonia, calla, arum, Mexican clover, and Chrysanthemum

Bulbs, corms, tubers, rhizomes (except from Israel, United Kingdom and Netherlands)

Vegetative propagating material of miscellaneous herbaceous plants (except from Netherlands and United Kingdom)

Sisal (except true seeds)

Vegetative propagating material of grasses (except Johnsongrass, which is prohbited)

Maize seed from all countries in Asia beyond 60° East Longitude

Rice Seed

Sugarcane vegetative propagating material

Groundnut vegetative propagating material and true seeds

Soybean true seeds

Lucerne vegetative propagating material

Sweet clover vegetative propagating material

Bean true seeds from areas where bacterial wilt occurs

Clover vegetative propagating material

Ginger, Cassava, yam, sweet potato vegetative propagating material

Cocoa vegetative propagating material

Potato tubers (except those from Eire, Netherlands and United Kingdom)

Potato true seed and tomato true seed from areas where potato spindle tuber occurs

Pineapples

Pepper vegetative material and true seeds from areas where blight occurs

Cucumber, and squash vegetative propagating material

Strawberry vegetative material (except certified stocks from United Kingdom)

Banana vegetative propagating material and true seeds

Tobacco true seeds

Vanilla vegetative propagating material

Grape vegetative propagating material

Mango vegetative propagating material (except Africa south of the Sahara)

Conifers from countries south of the Sahara, Fiji, Australia, New Zealand and Tanzania

Miscellaneous forest trees

Tea from countries south of the Sahara and where blister blight does not occur

Coffee vegetative propagating material

TABLE 2

TIME PHASING FOR ACTIVITIES SCHEDULED FOR REGION QUARANTINE LABORATORY SUBPROJECT

Activities	Year 1	Year 2	Year 3	Year 4
A. Recruitment and Posting of Personnel	18 ———	mos →		
(1) USAID technician a/ (Plant Pathologist Head)	- - - - →			
(3) Research Officer Trainees b/	6 mos →			
B. Staff Training and Development	———	24 mos ———	→	
(1) On-the-job experience at Muguga Station for Research Officer Trainee (Counterpart)	12 ———	mos →		
Advanced training for Research Officer Trainee - counterpart at US and Australian Quarantine facilities (Maryland, Hawaii, Florida, Louisiana, Australia.)		6 mos →		
(2) Research Officer Trainees to US for M.Sc. Degree (Pathology-virology)	24 ———	mos ———	→	
C. Transition of Responsibility to Counterpart			18 ———	mos →
D. Duration of USAID Project support	———	36 ———	mos ———	→

a/ The team recommends that the USAID technician currently at the Quarantine Station in Muguga, Kenya be extended for an additional two (2) years upon the completion of his current tour in June 1976.

b/ EAAFRO Staff members have indicated that at least one of these individuals has already been located

TABLE 3

TIME PHASING OF FINANCIAL INPUTS BY SOURCE FOR EAST AFRICAN PLANT QUARANTINE STATION

Input	Time and Cost		Total by Category		Source			
	Year(1)	Year(2)	USAID	Others	EAAFRO	AID	Partner State	Other
	$	$	$	$				
Personnel								
(1) USAID technician (Pathologist)	50,000	50,000	100,000			X		
(1) Research Officer (Horticulturalist)	5,140	5,140		10,280	X			
(3) Research Officer Trainees (Counterpart)	9,300	9,300		18,600	X			
(3) Scientific Assistants	7,200	7,200		14,400	X			
(8) Laboratory Assistants	8,800	8,800		17,600	X			
(1) Clerk-Typist	1,100	1,100		2,200	X			
(14) Auxillary Staff	9,000	9,000		18,000	X			
Casual Labor	2,860	2,860		5,720	X			
Participant Training								
(3) Research Officers to US for training(Path.)	31,050	27,000	58,050			X		
Commodities a/								
Fumigation Apparatus Incinerator	1,600		1,600			X		
Incubator and fluorescent lighting	1,500		1,500			X		
Mist propogation equipment	1,100		1,100			X		
Refrigerator	500		500			X		
Glassware, media and miscellaneous supplies	1,600		1,600			X		
Land and Structures								
Office, laboratory and storage	1,200	1,200		2,400	X			
Specialized green house space (6,240 sq.ft)	6,000	6,000		12,000	X			
Land (8 acres)	2,880	2,880		5,760	X			
Travel and Per Diem								
Outside East Africa	1,430	1,430		2,860	X			
Within East Africa	1,430	1,430		2,860	X			
Consumable Supplies b/	30,570	30,570		61,140	X			
TOTAL FOR PROJECT			164,350	173,820				

a/ Commodities to be supplied in the initial year by USAID are itemized in Appendix A.

b/ This category includes maintenance on quarantine related facilities and grounds.