A.I.D. EVALUATION SUMMARY PART I PAGE 1A

(BEFORE FILLING OUT THIS FORM, READ THE ATTACHED INSTRUCTIONS) PD-AAZ-893

IDENTIFICATION DATA

A. REPORTING A.I.D. UNIT: S&T/AGR/AP (Mission or AID/W Office) (ES#)

B. WAS EVALUATION SCHEDULED IN CURRENT FY ANNUAL EVALUATION PLAN? yes ☒ slipped ☐ ad hoc ☐ Eval. Plan Submission Date: FY ___ Q ___

C. EVALUATION TIMING interim ☒ final ☐ ex post ☐ other ☐

D. ACTIVITY OR ACTIVITIES EVALUATED (List the following information for project(s) or program(s) evaluated; If not applicable, list title and date of the evaluation report)

Project #	Project/Program Title (or title & date of evaluation report)	First PROAG or equivalent (FY)	Most recent PACD (mo/yr)	Planned LOP Cost ('000)	Amount Obligated to Date ('000)
936-4137	Biotechnology Plant Tissue Culture	84	8/89	5,000	3,894

ACTIONS

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

Action(s) Required	Name of officer responsible for Action	Date Action to be Completed
1. The Cooperative Agreement's goal modified to be: "Develop, demonstrate, and transfer validated methodologies for the regeneration and selection of stress-tolerant germplasm using a representative number of crops and stresses prevalent in the developing world."	J. Cohen, J. Bergman, M. Nabors	5/89
2. Immediate actions taken to plan and complete critical field and lab tests to verify cell technologies. These should be done through U.S.-based institutions and provide data for submission to Crop Science or equivalent refereed journal as agreed upon between AID and TCCP.	M. Nabors J. Cohen	3/89 and as needed
3. Fifth year workplan developed around four objectives of Cooperative Agreement and include critical tests for verification as described above. Approval of workplan made by ST/AGR.	M. Nabors	1/89

Revised 3/1/89

(Attach extra sheet if necessary)

APPROVALS

F. DATE OF MISSION OR AID/W OFFICE REVIEW OF EVALUATION: mo 1 day 10 yr 89

G. APPROVALS OF EVALUATION SUMMARY AND ACTION DECISIONS:

	Project/Program Officer	Representative of Borrower/Grantee	Evaluation Officer	Mission or AID/W Office Director
Signature / Typed Name	Joel I. Cohen	Colorado State U.	E. Roche	David D. Bathrick
Date:	3/2/89	3/8/89	3/4/89	4/3/89

A.I.D. EVALUATION SUMMARY PART I

(BEFORE FILLING OUT THIS FORM, READ THE ATTACHED INSTRUCTIONS)

IDENTIFICATION DATA

A. REPORTING A.I.D. UNIT: 3&T/AGR/AP (Mission or AID/W Office) (ES#)

B. WAS EVALUATION SCHEDULED IN CURRENT FY ANNUAL EVALUATION PLAN? yes ☒ slipped ☐ ad hoc ☐ Eval. Plan Submission Date: FY ___ Q ___

C. EVALUATION TIMING interim ☒ final ☐ ex post ☐ other ☐

D. ACTIVITY OR ACTIVITIES EVALUATED (List the following information for project(s) or program(s) evaluated; if not applicable, list title and date of the evaluation report)

Project #	Project/Program Title (or title & date of evaluation report)	First PROAG or equivalent (FY)	Most recent PACD (mo/yr)	Planned LOP Cost ('000)	Amount Obligated to Date ('000)
936-4137	Biotechnology Plant Tissue Culture	84	8/89	5,000	3,894

ACTIONS

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

Action(s) Required	Name of officer responsible for Action	Date Action to be Completed
4. That TCCP focus on a limited number of crops and stresses for its duration, especially regarding the project's proposed extension.	M. Nabors, J. Cohen	4/89
5. That TCCP in vitro activities be reduced to those essential for somaclone production needed for verification, except those undertaken by TCCP-supported graduate students.	M. Nabors	4/89
6. That other TCCP lab experiments in pathbreaking research (objectives D of Cooperative Agreement) be done as budget permits to fulfill other objectives of project and must be listed in approved workplan.	M. Nabors	4/89
7. TCCP look to external funding to support studies in CDNA and molecular biology and let current funding terminate on 10/1/88.	M. Nabors	1/89

Revised 3/1/89

(Attach extra sheet if necessary)

APPROVALS

F. DATE OF MISSION OR AID/W OFFICE REVIEW OF EVALUATION: mo 1 day 10 yr 89

G. APPROVALS OF EVALUATION SUMMARY AND ACTION DECISIONS:

	Project/Program Officer	Representative of Borrower/Grantee	Evaluation Officer	Mission or AID/W Office Director
Signature / Typed Name	Joel I. Cohen	Colorado State U.	E. Roche	David D. Bathrick
Date:	3/2/89	3/15/89		

A.I.D. EVALUATION SUMMARY PART I Page 1C

(BEFORE FILLING OUT THIS FORM, READ THE ATTACHED INSTRUCTIONS)

IDENTIFICATION DATA

A. REPORTING A.I.D. UNIT: S&T/AGR/AP
(Mission or AID/W Office)
(ES#)

B. WAS EVALUATION SCHEDULED IN CURRENT FY ANNUAL EVALUATION PLAN? yes ☒ slipped ☐ ad hoc ☐
Eval. Plan Submission Date: FY ___ Q___

C. EVALUATION TIMING Interim ☒ final ☐ ex post ☐ other ☐

D. ACTIVITY OR ACTIVITIES EVALUATED (List the following information for project(s) or program(s) evaluated; if not applicable, list title and date of the evaluation report)

Project #	Project/Program Title (or title & date of evaluation report)	First PROAG or equivalent (FY)	Most recent PACD (mo/yr)	Planned LOP Cost ('000)	Amount Obligated to Date ('000)
936-4137	Biotechnology Plant Tissue Culture	84	8/89	5,000	3,894

ACTIONS

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

Action(s) Required	Name of officer responsible for Action	Date Action to be Completed
8. TCCP technologies proven and verified in U.S. either before or concurrently with their planned use in LCCs; exceptions arising due to tropical germplasm and prior commitments to be agreed upon by AID&TCCP.	M. Nabors J. Cohen	3/89& as needed
9. TCCP be extended until August, 1990 to allow for data compilation and seed production. This extension based upon agreement of workplan and ability of TCCP to produce verification data.	M. Nabors J. Cohen J. Bergman	3/89

Revised 3/1/89

(Attach extra sheet if necessary)

F. DATE OF MISSION OR AID/W OFFICE REVIEW OF EVALUATION: mo___ day___ yr___

APPROVALS

G. APPROVALS OF EVALUATION SUMMARY AND ACTION DECISIONS:

	Project/Program Officer	Representative of Borrower/Grantee	Evaluation Officer	Mission or AID/W Office Director
Signature				
Typed Name	Joel I. Cohen	Colorado State U. E. Roche		David D. Bathrick
Date:	3/2/89	3/8/89		

H. EVALUATION ABSTRACT (do not exceed the space provided)

The project's main purpose (as cited in the CA) is to establish understandings with regard to A.I.D.'s support and stimulation of the Tissue Culture Research Program at C.S.U. The project is being implemented by Dr. Murray Nabors at C.S.U. in Ft. Collins, CO through numerous subgrants. This external evaluation was held to assess project performance to date, project probability of successfully achieving the project purpose and review the research hypothesis of the project.

The external review was carried out at Ft. Collins from February 29-March 4, 1988 and was directed by Raymond Kitchell, Development Management Consultant and included Drs. Plucknett, Frey, and Murashige. As indicated in the attached Project Officer's Report, the current Project Officer was not part of the final two days of the evaluation during which the team summarized their findings and developed their recommendations.

The major findings and conclusions as recommended by the team include:

1. Extension of the project to August 31, 1991 to permit a critical mass of field evaluations necessary to validate the research hypothesis.

1. Field testing should include three generations for validation of each species-selection regime.

3. An external technical advisory committee should be organized to help the project carry out field tests and germplasm activities.

4. The Management Review Group should make all decisions affecting the work program.

However, of greater value at this date, is a review of section E, Action Decisions, and Section J regarding reaching agreement on the fifth year workplan and budget. These items are also covered in the attachment described as Workplan Documents.

ABSTRACT

I. EVALUATION COSTS

1. Evaluation Team Name / Affiliation	Contract Number OR TDY Person Days	Contract Cost OR TDY Cost (US$)	Source of Funds
I. Evaluation Costs			
1. R. Kitchell, Development Mgt. Consultant	ST/AGR	OE Funds	
D. Plucknett, CGIAR Secretariat	ST/AGR	OE Funds	
K. Frey, Iowa State University	ST/AGR	OE Funds	
T. Murashige, University of California	ST/AGR	OE Funds	
2. T. Gill, S&T/AGR	ST/AGR	OE Funds	
J.Cohen, S&T/AGR/AP	ST/AGR	OE Funds	Total $18,000

2. Mission/Office Professional Staff Person-Days (estimate) 5 days

3. Borrower/Grantee Professional Staff Person-Days (estimate) 5 days

Revised 3/11/89

A.I.D. EVALUATION SUMMARY PART II

1. SUMMARY OF EVALUATION FINDINGS, CONCLUSIONS AND RECOMMENDATIONS (Try not to exceed the 3 pages provided)
Address the following items:

- Purpose of activity(ies) evaluated
- Purpose of evaluation and Methodology used
- Findings and conclusions (relate to questions)
- Principal recommendations
- Lessons learned

Mission or Office: ST/AGR/AP Date this summary prepared: Dec. 28, 1988

Title and Date of Full Evaluation Report:

1. Purpose of activity evaluated

The Tissue Culture for Crops Project has the potential to contribute cellular and molecular methodologies which could provide agricultural researchers the ability to generate stress tolerant varieties for use by farmers in developing countries. The support for this S&T/AGR project was based upon earlier recognition of the possibility which plant tissue culture techniques offered for the selection and screening of stress-tolerant cell lines. AID has been collaborating with the Colorado State University (CSU) in using plant tissue culture, specifically somaclonal variation, to produce these lines in the major cereals and representative legumes.

As stated in the Cooperative Agreement, (CA), the goal of the project's activities is to expand and accelerate the application of tissue culture research to LDC crop production problems by strengthening LDC capacity in this field and by linking and coordinating the worldwide research. The objectives of the CA are to:

1. Expand field testing of stress tolerant plants, developed with tissue culture techniques, by establishing or expanding collaboration with International Agricultural Research Centers and selected LDC research institutions.
2. Provide required training to LDC researchers to improve their capability in plant biotechnology for crop production problems in their country or region.
3. Establish and expand a network of research institutions to share technologies, information and materials.
4. Continue pathbreaking research research to apply tissue culture techniques to research on additional crops which are important in LDC agriculture.

2. Purpose of Evaluation

The evaluation team was assembled to assess the project's performance to date, review the development and research hypothesis, and to determine the project's probability in attaining its objectives. A set of issue statements was developed by the team's leader in conjunction with AID and TCCP. These issues highlight fundamental areas of concern with the project and include the following: (1) need for clarification of the project's purpose, (2) slow rate of research progress, (3) lack of sufficient information on the cost of producing outputs, and (4) a series of management difficulties.

It should be mentioned that the Scope of Work, team member selection and issues listed above were done under the direction of the previous project officer as the

Revised 3/1/89

SUMMARY

project officially changed from the RNR division to AP as of August 1, 1988 (Please see attached letter from T. Gill to M. Nabors). Thus they do not necessarily reflect options presented by the current project officer. It should also be mentioned that the first day of the evaluation consisted of presentations by TCCP staff members, the second and third day of open discussions with the last two days closed to just the review team. Thus the current project officer was not involved in nor aware of how recommendations were determined.

3. Findings and Conclusions

A.) As listed above, four categories of issues were developed around which the evaluation occurred. A "short list" of recommendations was presented in the Executive Summary and consisted of the following:

1. The project be extended, if possible, to August 31, 1991, to permit the critical mass of field evaluations necessary to validate the research hypothesis and achieve project purpose, contingent upon acceptance of Recommendation No. 3.
2. Field testing should include three generations for validation of each species-selection regime combination suggested.
3. An external technical advisory committee should be organized at once to help TCCP plan and carry out field tests and germplasm activities.
4. The Management Review Group should make all decisions affecting the work program needed to complete the project.

In addition, Section IV of the report, "Suggestions and Recommended Actions," contains 15 recommendations grouped under the headings of research (which includes verification, in vitro research, molecular biology/gene transfer, and management), networking and training, and management. Please consult pages 75-81 of the attached report for this listing as well as the attached Project Officer's Report for discussion of these suggested recommendations.

B.) In Section III, the report considers the four special issues for review. A summary of these follows. Issue I: Clarification of Purpose and Major Design Elements. This issue was developed to obtain a clear statement of the purpose of the project. However the goal and objectives stated in the CA were never cited in these discussions. The report (pages46-53) accurately points out the confusion which has resulted because of this problem. The agreed upon purpose, as stated in the report is well worth quoting as it succinctly states a realistic focus for the project. This is: "to develop, demonstrate, and transfer validated methodologies for the regeneration and selection of stress-tolerant germplasm using a representative number of crops and stresses prevalent in the developing world" (p.50).

Issue 2: Slow rate of progress. This concern arose regarding TCCP's apparently insufficient progress in achieving projected outputs, including field testing, and demonstration of results. To quote from the evaluation report (p.54):

"The basic research assumption in the TCCP is that some somaclonal variants of plants that arise from tissue cultures will provide useful traits for crop improvement. The proposed unique contribution of TCCP research was (a) to determine whether some somaclonal variants, caused by select stresses on plant

Revised 3/1/89

cells, had higher tolerance to corresponding edaphic, climatic, and biotic stresses and (b) to develop in vitro strategies for selecting callus cultures that were mutant for these stress tolerances. The success of both (a) and (b) must be validated by field testing progenies of regenerated plants from tissue culture that survive selection. The field test conditions must include the stress for which in vitro selection occurred in order to evaluate the validity of both."

Clearly this is the most important statement in the report. However, it has taken such a finding to begin reaching agreement on the real mission of the project. The problems which TCCP encountered in carrying out the mission described above were predicted based upon the lack of plant breeding, agronomic and statistical expertise within the project. In addition, the project lost sight of the hypothesis at hand: to demonstrate that stresses imposed on cells in vitro statistically correlated with regenerated progeny in the field, and that these technologies, once verified, should be transferred to LDCs.

Issues 3 and 4, cost-effectiveness and management, have been discussed elsewhere and can be referenced in the team's report.

4. Principal Recommendations.

The project officer has concentrated implementation of various post-evaluation recommendations by working with Dr. Nabors on the fifth year workplan for TCCP. The third, and hopefully final draft, will arrive here after the project's conference in Kenya. Extensive revisions of the first draft presented have already occurred, including informing Dr. Nabors for the first time of extensive budget reductions for TCCP to occur in FY 89. As can be seen by the proposed budgets included in the workplan attachments, the emphasis on field verification is being taken seriously. However, in Dr. Cohen's letter to Dr. Nabors of 12/15/88, that of the 19 field experiments proposed, only 5 have the potential to provide publishable data. We have requested further analysis on this item, including that TCCP and Colorado State University consider collaborative opportunities with other institutions.

In addition, the workplan will be restated in terms of the four objective established in the Cooperative Agreement. These objectives were never presented or discussed during the the evaluation. However, this is a critical step in renewing the proper focus of the project among all parties involved, ie. CSU, TCCP and AID.

Other recommendations include: that TCCP focus upon a reduced, and limited, number of crops and stresses so that limited funds can be spent over fewer objectives, which will provide more support for verification and cell technologies closer to dissemination; that TCCP cell technologies be limited to those which will provide proof of the project's hypothesis regarding stress selection and that other work be done as budget permits and to fulfill other objectives of the Cooperative Agreement; that TCCP technologies be proven and verified in the U.S. either before or concurrently with their planned use in developing countries.

5. Lessons Learned.

A. Project Design Implications

Concerns regarding the verification, testing, and production of stress-tolerant germplasm arise largely because the initial project did not adopt an integrated approach to the use of biotechnology. Future projects in plant biotechnology, in order to reach applied dimensions and generate agronomically useful cultivars, must take this learning experience into account. Integration of conventional and new technologies is being adopted throughout the private sector regarding the application of biotechnology. These models should be considered in new project design. In addition, strategic alliances to accomplish this integration should be developed from the outset which implies that centrally funded support should not be provided to one institution. This is a problem in getting CSU to agree to give up project funds to University of California, Davis.

S&T/AGR should begin immediately to develop concept paper regarding the follow-up to the use of new technologies in crop improvement. This second phase should consider recommendations made at the Agency-sponsored conference, Strengthening Collaboration in Biotechnology: International Agricultural Research and the Private Sector. Each technology workshop offered suggestions and activities which should be give serious consideration.

B. Broad Action Implications

Policy requirements need to be considered in follow-up projects that would involve genetic engineering as well as tissue culture. There are already projects in AID's portfolio that require similar vigilance as now being applied to the vaccine projects. However, new technologies offer potential to address long-standing concerns regarding crop improvement in developing countries. Consideration of new technologies for crop modifications should be demand-driven, involve the private sector from the beginning, have provisions for market and economic analysis, and rights for first refusal regarding the development of proprietary technology or germplasm.

Drafted: S&T/AGR/AP:JCohen:jc/ka:12/30/88:W4639f.

Revised 3/1/89

ATTACHMENTS

K. ATTACHMENTS (List attachments submitted with this Evaluation Summary; always attach copy of full evaluation report, even if one was submitted earlier)

K. List of Attachments

1. Project Officer's Report with Two Attachments
2. Final Report of the External Evaluation Team on the TCCP
3. Workplan Documentation Describing Agreement on 5th Year Plan
4. Comments Received from Murray Nabors and TCCP Responding to the Evaluation.

MISSION COMMENTS ON FULL REPORT

L. COMMENTS BY MISSION, AID/W OFFICE AND BORROWER/GRANTEE

L. Comments by AID/W Office and Grantee

1. The external evaluation panel successfully met the demands of the scope of work prepared for the evaluation. Limitations of this report and team have been discussed elsewhere. All questions posed by the panel were completely answered by TCCP personal and the evaluation team had their fullest cooperation.
2. The result's of research at TCCP were examined in detail. There is no reason to believe that these results were not examined in a professional and objective manner. However, the objectives and goal of the Cooperative Agreement were not presented at the evaluation meetings.The conclusions reached by the team regarding verification, breeding and statistical analysis are supported by the current Project Officer.
3. It should be mentioned that TCCP has generated an impressive record in terms of demonstrated regeneration techniques for a number of crop species in both the cereals and legumes. In this regard, the project has successfully met many of its original objectives as stated in the Cooperative Agreement. However, what has been lacking is verification of the first objective of the Cooperative Agreement.
4. The TCCP has made remarkable progress in the IPBNet and in training. However, it has had the most difficulty in working collaborately with institutions able to provide statistically-valid data regarding electrical coefficients, salt-tolerance and other mechanisms which would demonstrate that selected changes at the cell level have correlated with similar changes at the whole plant level in the field.
5. Comments from TCCP can be summarized as follows:
   a. In relation to future responsibilities regarding field testing by the TCCP, it was recommended that,"Either the Project Director or his Associate should assume direct responsibility for the field evaluations." Their response was, "Neither the Project Director nor Associate Director has experience in field testing. A reduction in staff cannot take place in the critical area of field testing if we are to achieve our goals. As previously noted, reductions have already been made in the tissue culture component, amounting to four full-time positions."
   b. The issue regarding the low use of subgrants, which is still an issue regarding support offerred from the University of California, was discussed in lieu of a some time of competition with the Science Advisor's Office. Also, "Subgrants have and do present administrative problems. The AID Contract Office is very slow to respond to requests for approval."
   c. Further details can be found in Attachment IV which outlines Dr. Nabors' concerns regarding the evaluation report.

Revised 3/1/87

Concerns regarding the verification, testing, and production of stress-tolerant germplasm arise largely because the initial project did not adopt an integrated approach to the use of biotechnology. Future projects in plant biotechnology, in order to reach applied dimensions and generate agronomically useful cultivars, must take this learning experience into account. Integration of conventional and new technologies is being adopted throughout the private sector regarding the application of biotechnology. These models should be considered in new project design. In addition, strategic alliances to accomplish this integration should be developed from the outset which implies that centrally funded support should not be provided to one institution. This is a problem in getting CSU to agree to give up project funds to University of California, Davis.

S&T/AGR should begin immediately to develop concept paper regarding the follow-up to the use of new technologies in crop improvement. This second phase should consider recommendations made at the Agency-sponsored conference, strengthening Collaboration in Biotechnology: International Agricultural Research and the Private Sector. Each technology workshop offered suggestions and activities which should be give serious consideration.

B. Broad Action Implications

Policy requirements need to be considered in follow-up projects that would involve genetic engineering as well as tissue culture. There are already projects in AID's portfolio that require similar vigilance as now being applied to the vaccine projects. However, new technologies offer potential to address long-standing concerns regarding crop improvement in developing countries. Consideration of new technologies for crop modifications should be demand-driven, involve the private sector from the beginning, have provisions for market and economic analysis, and rights for first refusal regarding the development of proprietary technology or germplasm.

Drafted: S&T/AGR/AP:JCohen:jc/ka:12/30/88:W4639f.

Revised 3/1/89

AID EVAL SUMMARY.
TCCP
Attachment 3/p.1
Workplan Documentation

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DEC 15 1988

Dr. Murray Nabors, Director
T.C.C.P.
Department of Biology
Colorado State University
Ft. Collins, CO 80523

Dear Dr. Nabors:

I wish to thank you and your staff for the time devoted to the revised fifth year workplan. You have made major accomplishments, both in content and in the requested budget reductions. It is clear that budget outputs for verification and cell technologies have been modified and reflects closer coordination. This is worthy of recognition and is duely appreciated.

I would like to take this opportunity to address a few items requiring attention and deserving of your consideration. I have numbered these for future reference or discussion.

1. My budget analysis (please see Enclosure I) indicates that management costs have been distributed within outputs; thus eliminating the previous management output. This is fine, but we still need to know, and thus indicate, the percentage of each output total ascribed to management.

2. On the budget page submitted with the prior workplan a Personnel Budget Distribution was provided. Please submit a similar table for the revised workplan listing the names of individuals remaining on the Project.

3. Please modify the workplan to agree with the cooperative Agreement's statement of goals and objectives. I have enclosed a copy of this page (Enclosure II) and suggest the following grouping by objectives:

Objective A to include outputs 2,a,b,c
Objective B to include outputs 4
Objective C to include outputs 3,a,b,c,d
Objective D to include outputs 1,a,b,c,d,e,f

4. I have indicated on Enclosure III which of the 19 field experiments, either ongoing or planned, may provide data appropriate for publication. I appreciate your attention to detail in this section as it has been most helpful. It appears

that verification data could be expected from Experiments 13,14,11,12, and 19. We would request further analysis here as we have stressed this aspect with you in our meetings in Washington. Please address this concern and reconsider other alternatives, such as opportunities with UC/D, especially for short-term lab results, and, longer terms field studies as seed becomes available.
Dr. Qualset has informed me that he would welcome a student from CSU to work with him at Davis which means only $15-20,000 would be transferred to UC/D.

5. Have the consultants (breeders, statisticians) provided input on the field experiments?

6. Have you explored opportunities for additional funding from C.S.U. or perhaps seed companies interested in this material? Perhaps there are other avenues of funding which could support efforts between C.S.U. and the U.C. There would be a great deal of mutual benefit gained from such collaboration and the scientists at UC/D seem quite positive.

Perhaps re-allocation of expenses in output 1 or 2 could be directed to UC/D by transferring some of the increase experiments to Dr. Qualset. This would all be done in an attempt to provide more publishable data.

If we can successfully come to agreement on these items, then a rapid turn-around on the workplan could be accomplished. We recognize that the project will run out of its allotted funding in April, 1989. Therefore, coming to agreement will complete a necessary step in requesting an unfunded extension.

I thank you for your cooperation and fully recognize how difficult this process has been. However, we have come far in the brief period of our mutual working relationship. I look forward to receiving the final draft of the workplan, and, in the future, the receipt of field results as they become available.

Once again I personally thank you for your time, patience, and effort.

Sincerely,

Joel Cohen

Joel Cohen
Biotechnology and Genetic
Resource Specialist
Office of Agriculture
Bureau for Science and
Technology

Enclosures
As stated

cc: S&T/AGR/AP, M. Hortik
S&T/AGR, D. Bathrick

TCCP - Revised Workplan Analysis: Budget

I. Output 1: Tissue Culture Methodologies

	Prior Report $ (1)	Status per 9/27/88	Revised Draft $ (2)	Notes
1a	20,656	Reallocate	45,954	Corn, millet
1b	225,150	Reallocate	59,181	Sel, & Reg.
1c	20,656	Reduce/Drop	11,786	NO3 reductase
1d	24,787	Retain as is	11,263	Cereal Protop.
1e	45,443	Retain as is	35,102	CIMMYT
1f	2,478	Reallocate	11,733	Molecular study
1g	86,755	Reallocate	None	(1g) is now (1f)
Subtotal:	425,927		175,010	(175,019)

II. Output 2: Verification

	Prior Report $	Status per 9/27/88	Revised Draft	Notes
2a	None	No Change	7,981	Green house
2b	268,112	Increase	281,194	Fld tests
2c	None	No Change	None	
Subtotal:	268,112		226,180	(226,175)

III. Output 3: IBPNET

	Prior Report $	Status per 9/27/88	Revised Draft	Notes
3a	78,492	Retain as is	89,174	Network
3b	6,198	Retain as is	17,954	MOAS
3c	6,197	Retain as is	5,985	IARC/CRSP
3d	None		None	
Subtotal:	90,886		113,112	(113,113)

IV. Output 4: Training

	Prior Report $	Status per 9/27/88	Revised Draft	Notes
4a	78,493	Retain as is	81,873	

V. Output 5: Management

	Prior Report $	
5a	113,608	Redone, put into 1-4 above, but report does not indicate percentage of each output

Grand Totals:	Prior	Revised
Subtotal:	708,287	596,177
Overhead:	268,746	223,201
	977,033	819,377

(1) Includes overhead (40%)
(2) Does not include overhead

w4822f

PROGRAM DESCRIPTION

TISSUE CULTURE RESEARCH

The purpose of this Program Description is to establish understandings with regard to AID's support and stimulation of the Tissue Culture Research Program at Colorado State University. AID's assistance to the University in this undertaking is in furtherance of a mutual interest to accelerate and expand the use of tissue culture research and the products of such research for improved crop production in LDCs.

It is understood that the University's program activities will take the following goals, objectives and activities into account.

I. Goal and Objectives

The goal of the program activities is to expand and accelerate the application of tissue culture research to LDC crop production problems by strengtening LDC capacity in this field and by linking and coodinating the worldwide research. The objectives of the Cooperative Agreement, in furtherance of that goal are to:

A. Expand field testing of stress tolerant plants, developed with tissue culture techniques, by establishing or expanding collaboration with International Agricultural Research Centers (IARCs) and selected LDC research institutions.

B. Provide required training to LDC researchers to improve their capability in plant biotechnology for crop production problems in their country or region.

C. Establish and expand a network of research institutions to share technologies, information and materials.

D. Continue "pathbreaking" research to apply tissue culture techniques to research on additional crops which are important in LDC agriculture.

II. Program Activities

A. General

The Recipient (CSU) will expand its involvement and increase its capabilities in several areas of plant biotechnology to assist interested LDCs to develop their own biotechnology interests as equal partners. The following interrelated programs in collaboration with AID are proposed to achieve these goals:

TCCP Revised Workplan Analysis: Verification

Note: As indicated in budget analysis, $226,180 is listed in the workplan for verification. Of the $281,194 alloted for field tests, $36,121 is reserved for experiments currently in progress while $182,179 remains for new activities.

Summary of proposed TCCP field experiments.

CROP	EXP #	PURPOSE	COLLABORATOR	DATA EXPECTED
Rice	1	Increase	L.S.U.	No
	4	Salt Screen	NIAB, Pakistan	Possible
	5	Increase	UPLB, Philip	No
	9	Increase	CIAT	No
	13	Salt screen	UPLB	Yes
	14	Acid tolerance	CIAT	Yes
Wheat	2	Increase	CIMMYT	No
	10	Helminthosporium	CIMMYT	No
	11	Salt screen	CIMMYT	Yes,1 Rep
	12	Salt screen	Pakistan, CIMMYT	Yes, 1 Rep
Sorghum	3	Selective Increase	U of A - Yuma	No
	8	Increase	U of A - Yuma	No
	15	FAW	U of GA	Yes
	16	Acid tolerance	U of GA	Observation
	17	Acid tolerance.	U of GA	Observation
	18	Agronomic trial	U of GA	??
	19	Drought gradient	U of A, Yuma	Yes
Millet	6	Initial salt screen	NIAB, PAKISTAN	No
	7	Increase	U of A, Yuma	No

w4834f

'CCP BUDGET FOR OCTOBER '988 - SEPTEMBER '989

Revised Budget Submission

	NETWORK	TRAINING	WHOLE PLANT	IN VITRO RICE	IN VITRO WHEAT	IN VITRO SORGHUM	IN VITRO LEGUMES	IN VITRO MILLET	IN VITRO CORN	WIDE CROSS	PROTO/SUSP	TOTAL
PERSONNEL	76280	66632	147930	34014	18022	10659	6061	971	3042	22083	15490	401184
TRAVEL	20000	6000	12500	0	0	0	0	0	0	1000	0	39500
MATERIALS	9605	2930	18627	4283	2269	1342	763	122	383	9040	1950	51316
OPERATING EXP	5799	5066	11246	2586	1370	810	461	74	231	1679	1178	30500
FIELD TESTING	0	0	12150	0	0	0	0	0	0	0	0	12150
PRINT/COPY	1426	1246	2765	636	337	199	113	18	57	413	290	7500
CONSULTING	0	0	4000	0	0	0	0	0	0	0	0	4000
TUITION	0	0	0	10908	0	0	0	0	0	889	3619	15416
SUBGRANTS	0	0	16961	8251	2344	0	0	0	7055	0	0	34611
SUBTOTAL	113111	81874	226180	60678	24343	13011	7398	1185	10768	35103	22526	596177
INDIRECT COSTS	45131	32669	87468	17863	8778	5191	2952	473	1481	13652	7544	223201
TOTAL	158242	114541	313648	78542	33120	18202	10350	1658	12249	48755	30070	819377

PERSON-YEAR DISTRIBUTION

Mgmt/Office	3.78	2.16	2.00	0.28	0.22	0.23	0.03	0.03	0.10	0.18	0.08	9.09
Research	0.00	0.00	2.60	0.00	0.38	0.00	0.25	0.00	0.00	1.00	0.00	4.23
Tech Support	0.00	0.00	3.90	1.25	0.50	0.50	0.10	0.00	0.00	0.00	0.00	6.25
Grad Students	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.25
Total	3.78	2.16	8.50	2.78	1.10	0.73	0.38	0.03	0.10	1.18	1.08	21.82
Cost/Person - Dir	29924	37904	26609	21827	22130	17823	19468	39500	107680	29749	20858	27322
Cost/Person - Tot	41863	53028	36900	28252	30109	24935	27236	55252	122495	41318	27843	37552

PROJECTED REVENUES

Electron Micro Grant				1340							740	2080
International Prog Grant											2000	2000
Training Tuition		36000										36000
Conference Support	2500											2500
Total	2500	36000	0	1340	0	0	0	0	0	0	2740	42580

Att. 3/p 8

REVISED BUDGET OCTOBER 1988 - SEPTEMBER 1989 — Original Budget

	MANAGEMENT	NETWORK	TRAINING	WHOLE PLANT	IN VITRO RICE	WHEAT	SORGHUM	LEGUMES	MILLET	CORN	MOLECULAR	WIDECROSS	PROTO/SUSP	TOTAL
PERSONNEL	76489	57438	60127	110338	35145	14235	18225	12306	3667	1509	49233	18010	26511	48323
TRAVEL	0	20000	3000	20000	0	0	0	0	0	0	0	2000	0	4500
MATERIALS	8355	4059	9589	15590	7178	2471	3471	1294	118	118	3942	8000	2530	66715
OPERATING EXP	9760	2080	2440	10600	4880	2360	2360	880	80	80	2680	3680	1720	43360
FIELD TESTING	0	0	0	20000	0	0	0	0	0	0	0	0	0	20000
PRINT/COPY	2440	520	610	2650	1220	590	590	220	20	20	670	20	430	10000
CONSULTING	0	0	1000	4000	0	0	0	0	0	0	0	0	0	5000
TUITION	0	0	0	0	10908	0	0	0	0	0	0	1600	7232	19740
SUBGRANTS	0	0	0	0	0	0	0	0	0	15000	0	0	0	15000
INDIRECT COSTS	38720	33555	30630	73088	19321	7843	9834	5865	1550	689	22553	12652	12445	268743
TOTAL	135764	117652	107395	256266	78652	27499	34480	20566	5435	17416	79078	45962	50868	977035

Overhead (39.9%)

PERSONNEL BUDGET DISTRIBUTION

Philip - GA Yuma — Subtotal ??

MGMT/OPS														
Murray	14030													14030
Gary	8100			12960	1620	1620	1620	1620	1620	810		810	1620	32400
Oluf	11264	11264	4506								18022			45056
Julie	19136	7974	4784											31894
Kerri		22782		2531										25313
Reagan	2531		2531	20250										25312
Sunitha			25515											25515
Glen			550		550	550	550	550	550		550		550	4400
Sue	3494	3484	3484											10462
Lee	1860	930	930	1860	1860	1860	1860	1860	930	465	1860	465	1860	18592
RESEARCH														
Harrison			8526											8526
Fariha						5882	5882							11764
Carol						6493								6493
Dan				19475										19475
Suresh								4253			17010			21263
Jolanta				15375										15375
Nitschka												16501		16501
David				6316										6316
John				5864										5864
Doug S.				2412			2412							4824
Ray													12000	12000
Poungpet													9744	9744
Sathish					9744									9744
Anna					7937									7937
Doug M.											2430			2430
Students	5018	2509		10036	5018	2509	4089	2509			2509			34190
BENEFITS	11056	8497	9301	13259	737	3002	1814	1516	567	233	6852	233	737	57807
TOTAL	76489	57439	60126	110338	27466	21915	18227	12307	3667	1508	49234	18009	26511	483320

PERSON-YEAR DISTRIBUTION

Persons	2.75	2.2	1.9	6.65	2.55	1	1.25	0.85	0.15	0.05	2.1	1.05	1.15	23.6
Cost/Person	49369	53478	56524	38536	30844	27499	27584	24195	36233	348320	37656	43773	44233	41317

AH3/9

September 26, 1988

Dr. M. Nabors, Project Director
T.C.C.P.
Department of Biology
Colorado State University
Fort Collins, CO 80521

Dear Dr. Nabors:

As per our phone conversation of Friday, September 9, 1988, I wish to officially inform you of the TCCP projected monthly budget for FY 1989, and present other information for your consideration. As you know, I accepted responsibilities for this project on August 1, 1988 and have since been formally involved in all Office of Agriculture reviews, preparation of evaluation documents and development of recommendations for the project based upon available project documentation.

While working on these matters, I was informed that TCCP is currently funded at $75,000 per month. The planned funding for FY 1989 is $650,000 as put into the Congressional Presentation. Therefore, as of April 16, 1989, monthly project spending should be reduced to $54,166. The budget for grant year 5 is thus approximately $800,000 with seven months at $75,000 and five months at $55,000.

I have received the report prepared by the evaluation team, your responses to that report, the project's fifth year workplan and budget. I look forward to our planned discussions which will bring all of these activities into focus. I would remind you that the point of reference for project objectives is the binding CA between A.I.D. and C.S.U.

On Friday, Dr. Hortik and I were able to visit with Jim Mieman. We discussed the MRG and decided it best to hold off on an immediate meeting until all items of immediate importance (finalization of workplan, budget and A.I.D. Evaluation) are completed.

I have scheduled meetings for us with Richard Newberg, Cal Martin and Lance Jepsen of the Africa Bureau. We will discuss Bureau support of the IPBNET Conference scheduled for Nairobi. I have been in communication with them regarding a pledge of $20,000 to the conference available in October or November. Also, we should discuss the proposed AID/W cable presenting conference detail.

Regarding future correspondence, please have all of it sent either through or from you, although it can originate from any member of your senior staff. If the letter is purely informational, then please label it as an Information Memorandum. If our action, signature, or approval is required then please label as an Action Memorandum and underline the action required or requested.

Sincerely,

Joel I. Cohen
Biotechnology Specialist
Office of Agriculture
Bureau for Science and
Technology

cc:
H. Hortik, S&T/AGR/AP

Drafted:ST/AGR/AP:JCohen:krh:09/26/88:W4569f

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D C 20523

SEP 23 1988

Dr. Murray Nabors
Project Director
TCCP
Department of Biology
Colorado State University
Fort Collins, CO 80523

Dear Dr. Nabors:

Upon a recent trip to UC/D for the "Population Genetics and Germplasm Resources in Crop Improvement" conference, I was able to visit with a number of scientists evaluating crop tolerance to drought and salinity. I would like to summarize these discussions for your consideration. I am very confident that C.S.U. collaboration with these individuals will add a new, and welcome, physiological and field dimension to T.C.C.P.

First, let me list the individuals I was able to meet.

1. Dr. Ted Hsiao, Professor of Water Science and Plant Physiology, Dept. of Land, Air and Water Resources.
2. Dr. Manny Epstein, Professor of Plant Nutrition and Botany, Emeritus, Dept. of Land, Air and Water Resources.
3. Dr. Cal Qualset, Director of Genetic Resources Conservation Program and Wheat Breeder, Dept. of Agronomy and Range Science.
4. Dr. Bill Rains, Professor, Dept. of Agronomy and Range Science
5. Dr. Jan Dvorak, Professor, Dept. of Agronomy and Range Science
6. Joe Omielan, Graduate Student, LAWS.

While not possible to highlight all of these discussions, there are several points I wish to present for your consideration. Expertise in physiological mechanisms corresponding to drought tolerance is available from Dr. Hsiao. His lab is equipped to run tests on plant tissue samples to determine if osmotic or turgor changes have occurred in somaclones derived from either susceptible or tolerant germplasm. His own specialized equipment is in place as well as access to numerous growth chambers, either lean-in or walk-in.

Expertise in determining cation selectivity coefficients is available within the Agronomy and Range Science Department. Here individual plants can be tested for the ratio of Na to K cations transported within the plant. Deviations in this ratio suggest either increased tolerance or susceptibility to salinity. Please see attached letter from Bill Rains.

Moving to whole plant field testing, I was informed by Drs. Qualset and Rains of a unique testing site on a private farm near Davis. This field can accommodate numerous salinity treatments in randomized blocks with either hill or rows being used as plots. Currently, Cal is screening wheat material on one portion of the field while Bill is conducting tests with cotton and safflower. Please see enclosed letter from Cal. It documents the results of the extensive investment ($225,000) by these growers to develop a selective environment.

Att.3/p.1a

Colorado State University

Tissue Culture for Crops Project
Department of Botany
Fort Collins, Colorado 80523
(303) 491-6996
Telex 3711418

DATE: September 19, 1988

TO: Joel Cohen, ST/AGR/AP

FROM: Murray Nabors, TCCP Murray Nabors

RE: Work Plan

To assist AID in making decisions about the future of the TCCP, we have offered some opinions and options. Please pay particular attention to the Revisions and Options section beginning on page 4. Note that the Work Plan is based on a monthly budget of $81,500; the impact of spending an extra $6,500 per month is to ultimately shorten the Project's life by 1 1/2 months. However, since so little money was spent in grant year one, it is still conceivable that the TCCP could operate eight to twelve months beyond the original C.A. end date if we receive a no-cost extension.

Please also note that the suggestions made in Tej's memo of March 3, 1988 (enclosed) in-so-far as possible, have been incorporated into this work plan.

This is a first draft. We look forward to receiving feedback and suggestions so that we can prepare the final document as soon as possible.

Enclosures

MWN/SJS

The Tissue Culture for Crops Project is a program of the United States Agency for International Development, implemented by Colorado State University under cooperative agreement # DAN-4137-A-00-4053-00.

Att. 1/8

September 25, 1987

MEMORANDUM

TO: S&T/AGR/RNR, T. Gill

FROM: S&T/AGR, J. Cohen J Cohen

SUBJECT: Review of Tissue Culture for Crops Project

As per your request, I have reviewed the preliminary proposal for the TCCP review scheduled for Feb. 29-March 4, 1988. I appreciate the opportunity to review this document and provide the following comments and suggestions:

1. Team Composition: I would agree with Dr. Donald Plucknett participating. However, there are other alternatives for the plant breeder and the biotechnologist. Suggestions are: Dr. Bruce Maunder, V.P. of Agronomic Research, Dekalb-Pfizer Genetics; Dr. G. Khush, IRRI; Dr. Virgil Johnson, Wheat Research, USDA; and Dr. Fred Miller, Texas A&M for the plant breeding side. Dr. Peter Carlson, Director of Research and Development, Crop Genetics International; Dr. Phil Ammirato, Manager of Developmental Genetics, DNAP, and Dr. R. H. Smith, Texas A&M.

These individuals are presented for your consideration because they are currently involved in the process of incorporating tissue culture technologies into cereal crop improvement programs. They have used stress selection, both <u>in vitro</u> and in conventional approaches.

2. Principal Participants: Besides those you have listed, I would include myself and a representative from one of the CRSPs.

3. Special issues for review: These have been very thoughtfully stated and certainly reflect the critcal issues to be discussed. However, I would add two others: (a) TCCP relations with conventional plant breeding ard the models to be utilized in this collaboration, and, (b) goal and focus of future international network conference.

cc: ST/AGR/AP, H. Hortik
ST.AGR, D. Bathrick

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D C 20523

July 22, 1988

Dr. Murray Nabors, Principal Investigator
Tissue Culture for Crops Project
Department of Biology
Colorado State University
Fort Collins, Colorado 80523

Dear Murray:

As project monitor of TCCP, this would be my last letter to you. As of August 1, 1988, Joel Cohen of our Office will take over the responsibilities of monitoring this project. You know Joel pretty well and I am sure he will help facilitate the project as well or better than I have been able to do. Please give him your full cooperation.

I want to take this opportunity to thank you and your staff for the good cooperation which we in A.I.D., and I personally, have received. With your commitment and hard work, the tissue culture studies grew from an initial $25,000 grant for 18 months to the current $75,000 per month level The project has accomplished a great deal and has assisted the LDCs considerably. Its major impact will not be felt, perhaps, for a few years. But I am sure this tool, this methodology, will help the LDCs in many significant ways.

I remember well the trials and tribulations both of us have gone through to keep the project on its keel. Our efforts were fruitful. A great deal of credit goes to you. I salute you for your dedication and for the job well done. This project will be a key accomplishment of your career and you should always be proud of that.

I close this letter with fond memories of my association with the project, especially the people who contributed much to the project. Please remember me to Oluf, Julie and Ray, Gary, Kerri, Sunitha, Reagan, Glen, Lee, Suresh, Ahmed, Akbar and Sathish. Over the years I have met many other good friends from the U.S. and overseas who have and are working with your project and whose company I have enjoyed. Please pay my respect to Drs. Harper, Meiman, Hautaluoma, Colbert and Kazi, who have helped and guided the project.
With personal regards.

Sincerely,

-TSG-

Tejpal S. Gill
Chief
Renewable Natural Resources
Office of Agriculture
Bureau for Science and Technology

cc: D. Bathrick
J. Cohen

6026g:TSG:dlm.

Attachment 1/p.1
Project Officer's Report

Project Officer's Report Regarding External Evaluation of the Tissue Culture for Crops Project (TCCP)

Project #: 936-4137
Cooperative Agreement #: DAN-4137-A-00-4053-00

I. The Cooperative Agreement

The agreement for the TCCP was entered into by the U.S. Agency for International Development (A.I.D.), grantor, and Colorado State University, grantee. The project began August 31, 1984 and is scheduled for completion August 31, 1989.

In compliance with general Office of Agriculture procedures, an external, mid-term evaluation was conducted from February 29, through March 4, 1988. A scope of work was developed, approved by Office of Agriculture (including selection of team members) and a list of issues developed.

II. Team Composition

The external evaluation team consisted of:

- Dr. Kenneth J. Frey, Distinguished Professor of Plant Breeding, Iowa State University
- Raymond Kitchell, Development Management Consultant
- Dr. Toshio Murashige, Professor of Horticultural Science and Plant Physiology, University of California
- Dr. Donald Plucknett, Scientific Advisor, CGIAR Secretariat

In addition, Drs. T.P. Gill and Joel I. Cohen were present representing A.I.D.

III. Introduction and Executive Summary

It is recognized that the production of stress-tolerant crop germplasm from either conventional or cellular manipulation is a difficult task. The TCCP utilizes the addition of NaCL, AlCl, and PEG to culture media for the selection of stress-tolerant cell lines. The project has been successful in the production of cell lines tolerating increasingly concentrated levels of salts and in regenerating plants from many of these cell lines. However, the project has not been successful in statistically verifying the tolerance to salts during growth in vitro with tolerance to field salts during growth at the whole plant level. Nor has the project been able to establish correlations between altered physiological mechanisms and salt-tolerant cell lines produced by somaclonal variation.

The verification of in vitro methodologies in the field is a difficult undertaking in itself; often requiring inputs, funding and time far beyond parallel investments in the laboratory. This portion of the project, both in terms of cost and time, were underestimated by C.S.U. and A.I.D. in the Cooperative Agreement and the Workplans. In addition, specialized technologies and scientific teams are required for such research. Minimally, this entails a stress physiologist, conventional plant breeder, biostatistician and cell biologist.

Upon visiting with numerous specialists in stress tolerance at UC/D and in keeping with the declining project budget, I would recommend that all international testing be curtailed until proper experiments can be conducted to determine if in fact stress-induced somaclonal variation corresponds with appropriate physiological or agronomic traits at the whole plant level. This work could be done with UC/D or other suitable collaborators such as Dr. John Boyer at University of Delaware or the USDA Soil Salinity Lab at Riverside, CA. The following experiments would be advised:

1. Measurement of physiological traits (i.e. turgor and osmotic pressure) as conducted by Dr. Ted Hsiau.

2. Measurement of the cation selectivity coefficient (i.e. Na/K cation transport) by Drs. Rains, Qualset and Estein

3. Whole-plant measurement of agronomic traits from somaclones grown on the UC/D salinity plots on Boswell Ranch.

IV. Scope of Work for Evaluation Panel

A.) The evaluation team was assembled to assess the project's performance to date, review the development and research hypothesis, and to determine the project's probability in attaining its objectives. A set of "issue statements" was developed by the team's leader in conjunction with AID S&T/AGR/RNA. These statements highlight fundamental areas of concern with the project and include the following: (1) need for clarification of project purpose, (2) slow rate of research progress, (3) lack of sufficient information on the cost of producing outputs, and (4) a series of management difficulties.

These issues, and responses by TCCP/CSU, provided background for the evaluation of the major components of the project: research, networking, training and management.

B.) It should be noted that the current Project Officer officially assumed responsibility for TCCP on August 1, 1988 (Attachment I). While I was able to attend the evaluation, I was not able to contribute to the team solution or its scope of

work (SOW), except through memo to Dr. Gill concerning my review of the SOW (Attachment II). Therefore, I am evaluating the recommendations of the team without the benefits of being privy to their closed deliberations on Thursday and Friday, March 3 & 4th. In addition, TCCP has already been addressing evaluation comments prior to my involvement.

V. Responses to the Scope of Work

A. Clarification of project purpose and objectives.

In none of the evaluation discussions at CSU was reference made to objectives as stated in the Cooperative Agreement. The CA itemizes four objectives:

1. Expand field testing of stress tolerant plants developed through tissue culture technologies.
2. Provide required training to LDC researchers in biotechnology.
3. Establish and expand a network of research institutions to share technologies, information and materials.
4. Continue pathbreaking research to apply tissue culture techniques to research on additional crops.

The team's report (p. 46-53) accurately points out the confusion, over-ambitious nature and lack of focus which has resulted from the lack of an attainable objective as related to items 1 and 4 above.

The agreed upon purpose statement on p. 50 is well worth quoting here and should be a principle recommendation of the evaluation. It is: "to develop, demonstrate, and transfer validated methodologies for the regeneration and solution of stress-tolerant germplasm using a representative number of crops and stresses prevalent in the developing world." Such agreement and clarification regarding the project's purpose would serve to stress the following key factors:

1) That TCCP serves to develop technologies carried out at the cellular level but which must be verified at the whole plant level and is responsible for both production and verification of such technologies.
2) That TCCP is not responsible for the production of stress-tolerant cultivars, rather production of in vitro-modified germplasm from which breeders may be able to produce cultivars.
3) That TCCP should focus on representative crops and stress-selection technologies which can be verified immediately.

In addition to reaching agreement on project purpose, a new understanding should be developed towards mandate crops and stresses. This issue was not discussed by the review team. The CA presents crops and stresses on an annual basis as follows:

Year 1
- Set up tissue cultures of soybeans, green beans, cowpeas, corn. Initially, 3 cultivars of each species to be used.
- Analyze hormone concentrations and types for legume tissue culture
- Stress tolerance mechanism developed for sorghum
- Stress tolerance in wheat with CIMMYT
- Regeneration (from suspension and protoplasts) of cereals: wheat, rice, corn, pearl millet, proso millet
- Heat-tolerant wheat
- Nitrate-efficient rice

Year 2
- Regenerated salt-tolerant wheat, rice and pearl millet
- Regenerated aluminum-tolerant wheat and rice
- Regenerated drought-tolerant wheat
- Greenhouse testing of above plants
- Obtain regeneration techniques for soybeans, green beans, cowpeas, corn
- Stress tolerance selection begins for corn and soybeans
- Sorghum salt-tolerance continues
- Cereal regeneration
- Heat-tolerant wheat and nitrate-efficient rice continues

Year 3
- "Greenhouse testing of a salt-tolerant cultivar of wheat, rice, pearl millet; of an aluminum-tolerant cultivar of wheat, rice and drought-tolerant cultivar of wheat."
- Continue regeneration with soybeans, green beans, cowpeas, corn.
- Continue legume tissue culture
- Field testing (unspecified) of salt-tolerant sorghum
- Regeneration of cereals continues
- Heat tolerant and nitrate efficient work continues

Year 4
- Demonstrable technology transferred to appropriate LDC labs.
- Experimental emphasis shifts to stress (NaCl, AlCl, or drought) on rhizobium-legume associations
- New stresses (aluminum and drought) added to sorghum research
- Greenhouse testing of cereals regenerated from suspension or protoplast culture
- Greenhouse testing of heat-tolerant wheat and nitrate-efficient rice plants.

Year 5
- All crops and stresses as above continues with greater effort on greenhouse and field testing.

B. Slow Rate of Progress

This issue was proposed by AID because of general concerns regarding TCCP's apparently insufficient progress in achieving

projected outputs, including field testing, and demonstration of results.

To quote from the evaluation report (p. 54):

> "The basic research assumption in the TCCP is that some somaclonal variants of plants that arise from tissue cultures will provide useful traits for crop improvement. The proposed unique contribution of TCCP research was (a) to determine whether some somaclonal variants, caused by imposed but select stresses on the plant cells, had higher tolerance to corresponding edaphic, climatic, and biotic stresses and (b) to develop in vitro strategies for selecting callus cultures that were mutant for these stress tolerances. The success of both (a) and (b) must be validated by field testing progenies of regenerated plants from tissue cultures that survive selection. The field test conditions must include the stress for which in vitro selection occurred in order to evaluate the validity of both."

The perceived poor performance and resultant concern voiced by AID results from a number of factors. The problems TCCP has encountered trying to conduct field tests are well documented (Report, p. 55). However, the project was not designed suitably for such extensive analysis nor did TCCP obtain timely guidance and cooperation. The Agency as well as C.S.U. should have realized this problem in assigning such responsibilities to a group generally unfamiliar with agronomy.

The team suggested that three more years of field testing are needed for validation of one species-solution regime combination. They also suggest an external advisory group be established to help TCCP plan and carry out field tests. The external group should consist of a "breeder, soils expert, statistician, and germplasm expert.

C. Cost-effectiveness

This issue refers to the lack of sufficient information regarding the cost of producing outputs and sub-outputs. These involve research, networking and training.

D. Management

The external evaluation team makes numerous references to the poor management at TCCP, i.e.: " the team has concluded that the poor quality of overall management has constrained the performance and quality of research and its products" (p. 37). However, no substantial personnel recommendations regarding management are presented in Section III of the report, except to commend a number of steps which have already been taken to correct such problems.

While management by objectives was praised by the team in relation to TCCP as a means to sharpen milestones and ending events, no management recommendations were made regarding TCCP personnel. Clearly, management performance has been hindered by many factors, including poor project construction at the onset. Efforts to correct this have been made through an external management consultant and efforts by TCCP to comply with Agency guidance.

Specific suggestions included:

o By June, at the latest, TCCP should begin to draft the annual progress report to AID on GY-4 and in July, also at the latest, should begin revising the workplan for GY-5 and extending it to cover any subsequent year(s) which may be necessary and approved to complete the project. It should be an integrated process with the MRG involved to the maximum extent attainable. These tasks should be considered top priority and scheduled in the workplan as any other important project work.

o The workplan should contain meaningful milestones, including defined and targeted ending events, for use in reporting (both quarterly and annual progress/management reports to AID and CSU), monitoring and review.

VI. Project Officer's Review of Panel Recommendations

1. The project should be extended through 8/31/91. Before extending, alternatives must be explored for focusing the project, developing collaborative teams with another U.S.-based institution specializing in stress, phasing down the training component and ammending the C.A.

2. Three generations of required field testing. This is an ideal goal, but not necessarily the burden of TCCP alone at this late stage.

3. Formation of an external TAC. Good idea.

4. The Management Review Group (MRG) should make all decisions affecting the work program. The new MRG should meet once the workplan, annual report and evaluation have been completed.

w4527f

CLARIFICATIONS TO FINAL REPORT ON TCCP EXTERNAL REVIEW

M Nabor's Comments on External Review

p. v **This TAC should consist of, at the minimum, one plant breeder, one soils expert, a statistician, and a germplasm expert.** A breeder and a statistician have been hired as consultants since April 1988. TCCP staff are currently working to gain the assistance of a germplasm and a soils expert.

p. iv **The cDNA cloning study seems ill-advised...** The use of cDNA is one of the standard methods to detect and isolate genes. The method has now provided us with the first successful evidence that can lead to detection of genes associated with salt stress.

p. 13 **Progress in developing techniques for selecting tissue cultures tolerant to environment stresses and regeneration of plants from stress-tolerant cell lines has, unfortunately, been less satisfactory to date.** In vitro selection techniques had been developed for NaCl in rice prior to the beginning of the current C.A. Approximately 8,300 plants have been regenerated from selected culture of all crops and all stresses and are listed in the inventory.

p. 13 **Planned heat tolerance screening was not achieved.** Heat tolerance selection in wheat is being performed by Dr. Zamora (sub-grant) in the Philippines. The agreement was initiated and research has been ongoing since October 1986.

p. 17 **Significant field testing could have begun as early as 1986.** Field evaluation began in 1985. Field testing was increased to include rice, sorghum and oats in 1986. Seed increases were performed in Texas, Georgia, Louisiana and the Philippines. A salinity test on oats was performed in Canada and in the Philippines for rice. (See Fig. 1.)

R:CLARIFIC.RVW

Field Sites Prior to 1987

Year	Crop	Location	Generation	Purpose
1985	Rice	LSU	R1	Seed Increase
		IRRI	R1	Seed Increase
1986	Rice	LSU	R1	Seed Increase
		Texas	R1	Seed Increase
	Sorghum	Texas	R1	Seed Increase
		Georgia	R1	Seed Increase, Acid soil, Insect
	Oats	Canada	R1	Salt

Figure 1. Slide presented at Review.

p. 25 **Of particular concern to the team were... the limited involvement of project senior scientists in the training...** Instructors for the Training Program include Dr. Jim Colbert, Dr. Oluf Gamborg, Dr. Harrison Hughes, Dr. Charles Livingston and Dr. Leigh Towill.

p. 32 **The work plan for Grant Year Two was not submitted to AID in draft form until the summer of 1987.** A separate Work Plan was not submitted for Grant Year (GY) 2. Work continued in GY's 2 and 3 as outlined in the approved March 1985 Work Plan. It was not clear to the grantee that yearly written work plans were required nor was any mention of this made by the Project Officer until March 1987. A Revised Work Plan for GY's 4 and 5 was submitted and approved in December 1987.

p. 33 **Until the appointment of an Associate Director, no one other than the PI seemed concerned with relating day-to-day, bench level operations to output production and the achievement of the project purpose.** This implies a lengthy delay in hiring the Associate Director. In fact, the search began in the spring of 1985, just months after the C.A. was funded and before the new TCCP facility was completed. Dr. Gamborg came on staff in August 1985 and became actively involved in Network expansion as well as work planning and implementation.

p. 34 **TCCP staff would say things regarding research status which was at odds with the documentation supplied, a symptom of confusion.** If that were the case, the committee should have requested clarification from appropriate staff, who were available throughout the week. The interpretation could also be that members evaluating the research did not have time to be fully informed. For example, note that written and verbal data on the field testing

which began in 1985 was supplied to the team members; on page 17 of the Evaluation document it is stated that "Field testing could have begun as early in 1986."

p. 36 **The low use of subgrants to involve U.S. and LDC institutions in project research is a disappointment.** Sub-grants were not used more extensively for lab research due to AID's concern for competition with the Science Advisor's Office. In short, we were told to limit them. To date, four sub-grants have been awarded, for a total of $115,896.00. In the past year and a half, the TCCP has also awarded several smaller Field Testing Agreement funds to institutions in the US and abroad, for a total of $9,500.00. The sub-grant component has been reduced considerably because the funds were needed to compensate for increased costs of meeting the research and development/field test commitments. The "research base" on the campus has also been reduced.

Sub-grants have and do present administrative problems. The AID Contract Office is very slow to respond to requests for approval, and in the most recent instance, when renewals of existing sub-grants were submitted to AID in December 1987, the Contracts Office did not return approval until March 1988, almost three months after funds were to be released causing, in one instance, loss of valuable R_2 and R_3 rice material due to lack of funds to support their maintenance.

p. 39 **Verification of stress tolerance under field conditions has been noticeably slow.** In early 1987 an integrated experimentation of systematically developing germplasm and field evaluation was initiated. The first plants from this experiment were put in the field for a seed increase in 1988 and will be evaluated in 1989 on stress.

p. 40 **In the "Special Focus"...there are some instances of duplication of the efforts of other institutions.** In 1987 we were using cells of Distichlis, which is a temperate climate, halophytic grass. The expected results were not forthcoming and we had verbal information that other laboratories were using the species. The research in Arizona is performed primarily with mesembryanthemum and concerns effects of salt tolerance stress on enzymes. At TCCP we are using Leptochloa fusca (kallar grass) which is a subtropical grass widely grown in Pakistan on highly saline, alkaline soils. Salt tolerance genes isolated from this species and transferred to rice is of immense value and of keen interest to LDC's.

p. 40 **Seed increases have not been adequately planned to expedite field testing and the use of off-season nurseries to speed-up seed increase and to increase the number of testing seasons has not been adequately considered.** With each season new information is gained from the field evaluations. The primary lesson is that it takes time. Even through, genetically, the traits developed in vitro would be expressed in the R_1 generation there are several problems with evaluating R_1 lines under stress as mentioned by the review team. Seed quality is often poor and good stands of R_1 seed are often difficult to obtain. Also, seed quantity is often low, not allowing for replicated trials in the R_1 generation.

Verification of plants or lines which survive or exhibit increased tolerance in one season requires two additional seasons in the same environment. Therefore, one season is required for a seed increase and three seasons are required in the same environment for confirmation of stress tolerance for a total of four growing seasons. Even if germplasm for in vitro selection was available in May 1985, before the TCCP facilities were available and during the first year of the current C.A., only two years of stress

evaluations could have been conducted by the review in February of 1988 and full confirmation of stress tolerance could not have been presented.

The TCCP is only one season behind the optimum presented here. The first season of stress evaluations were conducted in 1987 and the data was presented at the Review.

p. 60 **This issue refers to the lack of sufficient information on the cost of producing outputs and sub-outputs.** Financial data by sub-outputs was submitted to the evaluation team before their arrival at CSU (see pgs. 146-150 of the Evaluation document). The exact instruction given in the "issues" document was to "Prepare a financial analysis by output for 1980 - 1989".

p. 61 **The IPBNet Newsletters, four to date...** Five IPBNet Newsletters had been published at the time of the Review in March 1988.

p. 65 **A two year unfunded extension of the cooperative agreement is feasible.** A two-year unfunded extension of the C.A. is not feasible. As stated in the Tentative Plans for Field Evaluation of Regenerated Material Report submitted to the AID Project Officer in April 1988, currently committed funds will last through June 1990 if recommended changes in staffing are made and, as recently pointed out, if outside funding is secured for speakers to attend the 1989 IPBNet Conference.

p. 67 **It is unrealistic to assume that much of the cost of these trials will be picked up by the IARCs...** It has never been assumed that the IARC's would pick-up most of the cost of TCCP field trials. As previously stated, several Field Testing Agreements are in place and are proving to be an effective mechanism for collaborative research.

p. 67 **The Project Director, or Associate Director, should assume direct responsibility for the field evaluations.** It is unreasonable to expect the Director or Associate Director, both of whom are already engaged in other important areas of activity in the Project, to take on responsibility for this vital area. Currently the Whole Plant Testing Group, which consists of three M.S.-level agronomists with experience and expertise in field evaluations and is led by a Ph.D.-level scientist whose degree is in Plant Genetics and Breeding, operates very effectively with the expert assistance of a statistician and a Ph.D. agronomist.

p. 69 **Continue full support for the Molecular Biology program except cDNA cloning study.** Funding for the molecular biology component runs out October 1, 1988. Tissue culture work has already been cut to the bare minimum and resources transferred to the field testing component. Work on wide crosses, and cell genetics and fusion cannot continue without additional monetary support of at least $100,000 per year or further reduction of core staff.

p. 69 **Output SF-2. Eliminate cDNA cloning study.** cDNA cloning was never a part of this output. This Output has been USAID/PK supported.

p. 73 **The project will not be successfully completed by August 31, 1988, the end of its current term.** The current C.A. ends August 31, 1989.

p. 77 **Consideration should be given to extending Dr. Colbert's work on wide crosses.** Dr. Colbert is a collaborator in molecular biology but not in wide crosses. Current work in wide crosses is being performed by Dr. A. Mujeeb-Kazi at CIMMYT with the help of TCCP employee Nitschka ter Kuile.

SUGGESTIONS AND RECOMMENDED ACTIONS

Research

Verification

1. Action be taken at the earliest possible moment and top priority be given to plan and complete the critical mass of field trials...

a. Standard symbols of generation to refer to regenerated material are used at the TCCP. The field plans for the remainder of the C.A. were sent to the Project Manager in April 1988.

b. Evaluations in progress between November 1987 and October 1988 are listed in the attached Field Evaluations for Grant Year Four.

c. A proposed list of consultants and a specific Technical Advisory Committee are ready for approval.

d,e,f. In the Revised Work Plan germplasm release and seed storage will be included and all procedures for release through the Crop Science Society of America will be followed. This has already been discussed with Dr. Duncan, University of Georgia, who is responsible for the sorghum release through Crop Science.

In Vitro

2. In Vitro activities should be eliminated or curtailed. In the past year, the tissue culture component has been reduced by four persons. Currently one and 3/4 persons are involved. The remaining tissue culture is performed by graduate students for their degrees.

3. Provision should be made for the adequate storage of seed. A cold storage chamber has been purchased and installed. The facility can accommodate all seed currently in the Regenerate Seed Inventory.

Molecular Biology

4. Current modestly funded work plans for "special focus" activities should be continued...

p. 69,77. SF-2. The research is funded by USAID/PK and the Nuclear Institute of Agriculture and Biology, Pakistan.

SF-3. The research output in molecular biology is concerned with identifying and isolating genes associated with salt tolerance. Since the Review, research results have been obtained on the expression of particular genes in response to salt stress. Excess complementary DNA (cDNA) was isolated from salt stressed kallar grass cells after m-RNA-cDNA hybridization. The non-hybridized cDNA includes expected salt stress related sequences which are being used as probes to identify the genes linked to salt stress in the halophytic grass.

Research on salt stress induced elevation in gene expression in rice has resulted in production of proteins which are new or increase under salt stress. The proteins are produced within one day when cells are grown in media with 1 to 3% salt. The proteins range in size from 22-28 KD. The results are the first evidence of specific proteins being produced by rice during salt stress.

Dr. Ray Bressan, Purdue University, is spending the next six months on sabbatical at CSU. He will participate in the molecular program. He is one of the few who have been involved in molecular biology of salt stress for several years. A collaborative program is being planned between Dr. J. Colbert, who is moving to Iowa State University, Dr. R. Bressan, and the TCCP.

Management

5. Research management should concentrate on designing, scheduling, seeking collaborative partners, facilitating and monitoring field trials and evaluations.

a,b. The work plan for GY 5 is currently in the early stages of preparation.

c,d. Publications for internal (AID) and external use, are in preparation. A schedule of these will be included in the work plan.

e. Meetings of the CSU Advisory Committee are being planned for the next year.

7. Training should be continued...but a CSU advisory team should review the program... Efforts are being made to identify and appoint a training advisory team.

Management

8. ...a management system based on results (outputs) should be adopted by TCCP staff... The TCCP staff is concentrating its efforts on field evaluations and the expected stress-tolerant plant lines (outputs).

10. The preparation of the annual TCCP progress report to AID...should begin immediately. Preparation of the annual report (due December 31) will begin as soon as a draft of the work plan is submitted—in September.

11. The work plan should include management as a major component... The GY 5 work plan will include a management section including planning, reporting, and scheduling outputs.

Networking and Training

6. The IPBNet should be nurtured and supported to the maximum extent possible. a. Recent IPBNet projects, particularly the Directory, have been aimed at linking scientists who have interest in various plant technologies—

not limited to tissue culture—including breeding and molecular biology. The Second IPBNet Conference included a session on novel technologies as will the Third IPBNet Conference.

b. Plans are already underway to hold the Fourth IPBNet Conference at CATIE in Costa Rica. This is contingent upon continued funding from AID.

c. Efforts are being made to expand networking in the U.S. and abroad to include additional collaborators, particularly in field testing, and also in molecular biology.

13. **Either the Project Director or his Associate should assume direct responsibility for the field evaluations.** Neither the Project Director nor Associate Director has experience in field testing. A reduction in staff cannot take place in the critical area of field testing if we are to achieve our goals. As previously noted, reductions have already been made in the tissue culture component, amounting to four, full-time positions.

IV/12

FIELD EVALUATIONS FOR GRANT YEAR FOUR

Location	Crop	Stress Environment	Planting Date	In vitro Stress	Number of Lines R1	R2	R3	R4	Total
Pampanga, Philippines	rice	salt	01/88	no-stress		93**			93
				salt		273			273
				Total		366			366
Crowley, Louisiana	rice	increase	05/88	no-stress	10				10
				aluminum	62				62
				salt	148				148
				susp. culture	65				65
				Total	285				285
Santa Rosa, Colombia	rice	acid	05/88	no-stress		10			10
				salt		31			31
				aluminum	35				35
				Total	35	41			76
UPLB, Philippines	rice	increase	07/88	no-stress	26				26
				salt	171				171
				Total	197				197
NIAB, Pakistan	rice	salt	07/88*	no-stress		33**			33
				salt		29			29
				Total		62			62
Griffin, Georiga	millet	acid	05/88	no-stress		15			15
				salt		19			19
				Total		34			34
Griffin, Georgia	millet	increase	05/88	no-stress	157	15			172
				salt	94	19			113
				aluminum	43				43
				Total	294	34			328
NIAB, Pakistan	millet	salt	07/88*	no-stress	7	9			16
				salt	9	34			43
				Total	16	43			59

Location	Crop	Stress Environment	Planting Date	In vitro Stress	Number of Lines R1	R2	R3	R4	Total
Yuma, Arizona	millet	increase	07/88	no-stress	229				229
				salt	7				7
				Total	236				236
ICRISAT, India	pigeonpea	salt	03/88	no-stress	3				3
				salt	18				18
				Total	21				21
Ft. Collins & Cortez Colorado	pigeonpea, moth beans & tepary beans	increase	06/88	pigeonpea					
				no-stress	3				3
				salt	1				1
				moth beans					
				no-stress	16				16
				salt	16				16
				tepary beans					
				no-stress	11				11
				salt	4				4
				Total	51				51
Puerto Rico	sorghum	increase	11/87	no-stress			23		23
				salt			18		18
				aluminum	30				30
				Total	30		41		71
Botswana	sorghum	drought	01/88	no-stress			6		6
				salt			4		4
				Total			10		10
Yuma, Arizona	sorghum	drought	04/88	no-stress		54	22		76
				salt		41	78		119
				Total		95	100		195
Griffin, Georgia	sorghum	acid	05/88	no-stress	23		108**	5**	136
				aluminum	55				55
				salt			29	1	30
				hyd proline	16				16
				clorate	43				43
				Total	137		137	6	280

IV/14

Location	Crop	Stress Environment	Planting Date	In vitro Stress	Number of Lines R1	R2	R3	R4	Total
Griffin, Georgia	sorghum	increase	05/88	no-stress	108		29	6	143
				salt	16		155		171
				aluminum	91				91
				hyd proline	17				17
				clorate	46				46
				Total	278		184	6	468
Tifton & Plains, GA	sorghum	fall army worm/sorghum midge	06/88	salt			4**		4
				Total			4		4
Zimbabwe	sorghum	drought	06/88	no-stress			15		15
				salt			5		5
				Total			20		20
Yuma, Arizona	sorghum	increase	07/88	no-stress	31				31
				aluminum	8				8
				Total	39				39
CIMMYT, Mexico	sp. wheat	increase	04/88	no-stress	137				137
				salt	1,165				1,165
				Total	1,302				1,302

* Seed sent but planting date not confirmed.
** Second evaluation of all or part of the lines.

FINAL REPORT

of the

EXTERNAL EVALUATION TEAM

on the

TISSUE CULTURE FOR CROPS PROJECT

(TCCP)

prepared by

Dr. Kenneth J. Frey

Distinguished Professor of Plant Breeding

Iowa State University of Science and Technology

Raymond E. Kitchell

Development Management Consultant

Washington, D.C.

Dr. Toshio Murashi e

Professor of Horticultural Science and Plant Physiology

University of California

Riverside

Dr. Donald Plucknett

Scientific Advisor

CGIAR Secretariat, IBRD

Washington, D.C.

June 15,1988

Foreword

The Tissue Culture for Crops Project (TCCP) is one of several soil and water projects supported by the Renewable Resources Division of the Office of Agriculture within the Bureau for Science and Technology of the Agency for International Development (AID). These related projects focus on subject matters ranging from soil management and rainfed agriculture to biological nitrogen fixation and agriculture decision support systems. It is no coincidence that soil, water, weather, and germ plasm are key ingredients in all of these AID projects.

The TCCP project was designed to counter the problem of the high cost and energy intensive practices of agricultural development in the least developed countries. It was a selected program reaction to the proposition that it would be more economical if the plant could be modified to suit the environment than to modify the environment to suit the plant.

Based on an early recognition of the possibility of plant tissue culture techniques in screening for stress-tolerant cultivars, AID has been collaborating with the Colorado State University (CSU) in using plant tissue culture to demonstrate its use as a tool for plant breeders in the LDCs to obtain different levels and types of stress tolerance in plants.

The principal focus of the TCCP has been on somaclonal variation although in 1986, limited seed-funding was made available for experimentation with techniques involving, among other things, plant protoplast technology and molecular biology to isolate and transfer genes for stress tolerance traits.

This AID-funded research has been going on since 1979 and on a fully funded basis since 1985. The planned laboratory and greenhouse activity is nearing completion and field testing is just beginning. This report of the External Evaluation Team of the TCCP provides AID, and its collaborating partner, the CSU, with an objective analysis and assessment of progress to date and recommendations for the future.

EXECUTIVE SUMMARY

This summary is a part of, and not intended as a substitute for, the full report by the External Evaluation Team on the comprehensive, midterm evaluation of the Tissue Culture for Crops Project (TCCP). It is a highly summarized and incomplete version of selected observations, conclusions and recommendations cast in the framework of the purpose of the exercise, viz., (a) to assess performance to date; (b) on the basis of this assessment, to project the probability of successfully achieving the project purpose within the timeframe and resources provided; and (c) in the light of changes since project approval, to review the current validity of the development and research hypotheses and the project approach.

Performance:

Research

o Analysis of the current (Mar. 1988) status of the development of techniques for somaclonal variation clearly shows that: (a) the project has progressed rapidly in obtaining information on cell culture, stress tolerance selection, and plant regeneration steps *in vitro* for cereals and grain legumes which can be used for the development of protocols useful for isolation and selection of somaclonal variants for food crops; and (b), verification of stress tolerance under field conditions has been noticeably slow and disappointing.

o Outstanding progress has been made to date in producing wide crosses in wheat and promoting gene exchange but field trials are still necessary. Good progress has been made with sexual crosses with alien species and, on the whole and in consideration of the limited resources made available, progress on "special focus" activities has been very good.

o Greenhouse studies have not been appropriately conducted to permit statistical analysis and there has not been a sufficiently systematic approach to linking lab results with field testing and validation of the methodology.

o The assessment of performance by research outputs is:

Somaclonal selection - as expected or less
Wide crosses and gene exchange - very good
Hybrids by cell fusion - as expected
Molecular biology and cell genetics - as expected
Verification (field trials) - less than expected.

Networking

o The performance of the International Plant Biotechnology Newtwork (IPBNet), started by the TCCP, has exceeded realistic expectations and is fulfilling a real need. TCCP staff have been responsive to member requests and provided useful services. TCCP has been weakest in involving other U.S. universities in an advisory or collaborative manner in its research program and in fostering too narrow a focus for IPBNet.

Training

o The training program has proven to be quite useful as a device for involving LDCs and performance is rated as above average. Nevertheless, some problems were observed.

Management

o Less than adequate management performance has been manifested by: poor and late reporting to AID; static and untimely workplanning; insufficient emphasis on producing outputs (especially in research management); short-term focus on level-of effort; ineffective use of outside advisory expertise; and missed opportunities to involve AID and CSU in joint, substantive decision-mak..ng.

Assessment

o Overall, with exceptions at both ends, project performance to date can be described as adequate, average, and/or as expected.

Major Conclusions:

Research

o There has been some ambiguity and resultant confusion regarding the purpose of the TCCP, the research hypothesis to be tested, and the methodology to be employed in validating it. This has contributed to some of the management and communication problems which are now being resolved by the concerted efforts of both parties.

o TCCP has been exceedingly slow in conducting field experiments to evaluate whether some somaclonal variants are stress tolerant or whether in vitro selection was effective for detecting stress tolerant variants.

o Deficiencies noted in the field evaluation program conducted to date indicates that TCCP: (a) did not fully appreciate the significance of field verification tests to the purpose of the project; (b) conducted field evaluation on an ad hoc basis; (c) did not give enough attention to the

importance of statistical control and inferences in summarizing data; and (d) was still undecided whether the purpose of the project was "development of technology/methodology" or "development of germ plasm".

o Coordination between in vitro work and field studies in the collaborative work with CIMMYT on salt tolerance in wheat has been very good with progress clearly related to plans for seed increase and field testing.

o The cDNA cloning study seems ill-advised since the group in Arizona has already done related work but the bacterial plasmid work in Pakistan would be something to explore further.

o An unexpected development of considerable significance, lending support to the concept that untapped/unknown variations are possible or likely, occurred in the AL tolerance trial in Georgia where sorghum lines resistant to fall army worm and midge insects were produced. No such tolerance is known to exist for these insects anywhere in the world.

Networking

o IPBNet needs to be continued and nurtured, irrespective of the eventual fate of TCCP.

o TCCP needs to renew its efforts to involve other U.S. institutions, IARCs and NARCs, particularly in field testing.

o The focus of IPBNet (not TCCP) should be broadened from use of somaclonal variation to use of a wider array of methodologies in cell biology and the more promising aspects of molecular biology.

Training

o The training course, along with the visiting scientist program, has been a vital part of IBPNet and TCCP.

o Nevertheless, the program has encountered problems and the experienced gained should be evaluated preparatory to determining future directions and needs beyond project completion.

Project Management

o While there have been some recent and effective actions taken by CSU and AID to improve both research and project management, inadequate management and poor communication has constrained the performance and quality of TCCP research and its products.

o Its most unfortunate ramifications are demonstrated, at least in the first three critical grant years, by the apparent

inability of TCCP management to: (a) effectively involve AID in substantive and timely decision-making; and (b) provide the technical and management leadership necessary to validate the research hypothesis and achieve the project purpose within the timeframe and resources provided.

o AID was finally able to resolve the management difficulties with TCCP with effective support from CSU.

o At this point, research management must be focused on the design, conduct, and evaluation of field trials.

Project Success:

o The ~~the~~ development hypothesis on the importance of attempting to change crop characteristics to fit the environment was and is still valid.

o The validity of the research hypothesis, particularly as it pertains to somaclonal variation techniques, remains to be provenin the field trials and their evaluations.

o It is likely that several stress-tolerant cultivars of crops important to the developing world will be developed upon project completion.

Recommendations:

1. The project should be extended, if possible, to August 31, 1991, to permit the critical mass of field evaluations necessary to validate the research hypothesis and achieve the project purpose (conditional on acceptance of Recommendation No. 3).

2. Field testing should include three generations for validation of each species-selection regime combination suggested.

3. An external technical advisory committee should be organized at once to help TCCP plan and carry out field tests and germ plasm activities. This TAC should consist of, at the minimum, one plant breeder, one soils expert, a statistician, and a germplasm expert.

4. The Management Review Group (MRG) should make all decisions affecting the work program to complete the project. As soon as CSU and AID have completed their internal review of the evaluation report, a meeting of the MRG should be scheduled

to initiate action on accepted recommendations and revise the workplan accordingly.

List of Commonly Used Acronyms

AGR-Office of Agriculture

AID-Agency for International Development

CA-Cooperative Agreement

CGIAR-Consultative Group on Internation Agricultural Research

CRSP-Cooperative Research Support Program

CSU-Colorado State University

EOPS-End-of-Project-Status (indicators)

GY-Grant Year

IARC-International Agricultural Research Center

IPBNet-International Plant Biotechnology Network

LDC-Least Developed Country

MOB-Management-by-Objective

MRG-Management Review Group

PI-Prinicpal Investigator

PTC-Plant Tissue Culture

RNR-Office for Renewable Natural Resources

S&T-Bureau for Science and Technology

TAC-Technical Advisory Committee

TCCP-Tissue Culture Crops Project

TOR-Terms of Reference

Table of Contents

Description	Page No.
Foreward	i
Executive summary	ii
Commonly used acronyms	viii
I. Introduction	1
A. Purpose of Exercise	1
B. Project Background	1
C. Evaluation Methodology	3
II. Assessment of Project Performance	5
A. Description of Major Components	5
1. Research and development	5
2. Networking	8
3. Training	10
4. Technical assistance	11
B. Progress in Producing Results/Outputs	13
1. Stress tolerance selection using standard PTC methods	13
2. Stress tolerance selection using molecular and genetic procedures combined with PTC	14
3. Verification, seed production and distribution of improved cultivars	16
Exhibit No. 1-Status of research	18
4. International Plant Biotechnology Network	19
5. Training	23
6. Project management	26
C. Overall Assessment	39
Exhibit No. 2-Summary of performance ratings	42
III. Findings and Conclusions	46
A. Special Issues for Review	46
1. Clarification of purpose and major design elements	46
2. Slow rate of progress	53
Exhibit No. 3-Field evaluations	58
3. Cost-effectiveness	60
4. Management problems	63
Exhibit No. 4-Level of effort	69
B. Project Logic	71
1. Current validity of development hypothesis	71
2. Current validity of research hypothesis and project approach	71
3. Probability of successful project completion	73
C. Assessment of Effectiveness and Impact	72

IV. Suggestions and Recommended Actions 75

APPENDICES;

1. AID Evaluation Requirements 82
2. Evaluation Participants 88
3. CSU Reply to Issues 89

I. INTRODUCTION

A. Purpose of Exercise

In accordance with the Agency for International Development (AID) requirements for midterm evaluations,[1] an external evaluation team was assembled to:

- o assess the performance to date
- o on the basis of this assessment, project the probability of successfully acheiving the project purpose within the timeframe and resources provided; and
- o in the light of changes since project approval, review the development and research hypotheses and the project approach[2]

B. Project Background

The "Green Revolution" of the '60's, with its historic genetic breakthroughs, developed "miracle" crops which greatly increased the production of rice, wheat, and other crops in many areas of the world. Nevertheless it had a cost i.e., the

---

[1] See Appendix No. 1 for description of these requirements.

developing countries had to adopt energy intensive prac' ices. That meant they needed fertilizers, pesticides and herbicides which were beyond the reach of many of the least developed countries and marginal farmers. This gave rise to the proposition that it would be more economical if the plant could be modified for lower input and management needs than to modify the enviornment to suit the plant. Plant tissue culture was developed during the past few decades as a plant propagation technique using orchids, sugarcane, tobacco and carrots. After a preliminary experiment with tobacco, in 1979 a research contract was awarded to Colorado State University (CSU) by AID at an annual rate of about $150,000 to work on a few crops and stress factors prevalent in the developing world.

In 1983, progress was sufficient for the Division of Renewable Natural Resouces of the Office of Agriculture, Bureau for Science and Technolog (AID/S&T/AGR/RNR), to recommend an accelerated and expa ded research and development (R&D) prog' am in the plant tissue culture area, emphazing somaclonal variation but also including limited "pathbreaking research", training, and networking. Along with this increase in effort, which was accompanied by a CSU commitment to expand laboratory, office and training facilities, and in recognition of the rapidly developing field of plant biotechnology, it was decided that a more flexible and collaborative mode of joint management, such as that afforded in a cooperative agreement, would be more appropriate. The need for increased management capability was

also recognized, including use of outside advisory groups.

C. Evaluation Methodology

The exercise began in the summer of 1987 with the preparation of the issues for review which reflected the current concerns of AID management. At the same time, communications were sent to CSU, at the TCCP level and to the Vice President for Research, expressing concern that (a) the workplan had not been revised since early 1985, and (b) that the TCCP reporting was not providing AID with the type of information required, or in a timely manner, to monitor project operations, participate in joint decision-making, or review progress. Shortly thereafter, the "issue statements" proposed for the external evaluation were also sent to the University. As will be explained later, this led to joint sessions which resulted in AID providing some additional guidelines on reporting and work planning and th initiation of remedial actions on the part of CSU and TCCP staff. As part of the preparatory phase, TCCP staff drafted a written reply to the issues (Appendix No. 3) and prepared additional data for the evaluation as requested by the AID Project Officer. Approximately one month before the evaluation, team members were provided with the documentation listed in its TOR, including copies of publications, reports, official project papers, etc. In most cases, this documentation was well done. However, two critical documents, i.e., an output budget and expenditure spreadsheet and a status chart on R&D were not adequately prepared by TCCP management staff causing

some regretable delay while they were redone by TCCP or the team itself. The evaluation review, which lasted five days on campus, began on Monday, February 29, 1988, with introductory statements by officials of CSU, AID, and the evaluation team leader. For the remainder of the day, TCCP officials made oral presentations regarding their areas of responsibility. On Tuesday and Wednesday, the team members interacted with TCCP staff on the issues. Thursday and Friday, the team made a detailed appraisal of all outputs and suboutputs, down to at least the major activity level, and developed its consensus on major findings, conclusions, and recommendations. Based on subsequent inputs from the team, the team leader prepared a draft report based on an agreed-upon format, sent it to the team for final approval, and submitted the finished report to AID and CSU.[2]

---

2 See Appendix No. 2 for names and titles of participants.

II. ASSESSMENT OF PROJECT PERFORMANCE

A. Description of Major Components

1. Research and Development

A brief but excellent description of the TCCP research program is provided in a brochure entitled "Tissue Culture for Crops Project - Stress Tolerance Through Plant Biotechnology" from which the following is extracted:

The TCCP research objective is to develop and demonstrate the use of tissue culture methodology for rapidly and efficiently developing stress-tolerant plant cultivars.

(1) First, the Project seeks to develop methodologies for improved stress-tolerant germplasm and methods for rapidly cloning useful plants.

a. Obtain high-frequen y long-term plant regeneration of selected cultivars of rice, wheat, millet, corn, sorghum, soybeans, cowpea, and common bean.

b. Develop techniques for selecting tissue cultures and regenerated plants tolerant to heat, salt, drought, and aluminium.

c. Develop techniques for using tissue culture to promote gene introduction in wide crosses of wheat and/or corn.

d. Develop techniques for selecting tissue cultures and regenerated plants more efficient at utilizing nitrate and phosphate.

e. Develop techniques for obtaining high-frequency plant regeneration from selected cereal cell suspensions and protoplasts.

f. Develop techniques for cloning nitrate reductase into protoplasts.

(2) Second, the Project seeks to verify stress-tolerance selection techniques through greenhouse and field testing of whole plants.

a. Obtain greenhouse test results showing whether or not tissue culture selection techniques can give rise to stress-tolerant and fertilizer-efficient plants.

b. Obtain field test results for several crop species showing whether and to what extent greenhouse tolerant plants show tolerance in the field.

c. Obtain seeds with increased field tolerance for one or more stresses for distribution to plant breeders.

In this same publication, TCCP strategies were summarized as:

A. In vitro Methods for Producing Stress-tolerant plants

Plant Tissue

Callus/Culture Cell Suspension

Culture under stress

Stress-tolerant Cells

Plant regeneration

Stress Tolerant Plants

B. Plant Evaluation Under Stress Conditions

1. Greenhouse-hydroponics and soil testing
2. Field plot evaluation
3. Genetic analysis
4. Field performance - yield

The crops employed include, both cereals: rice, wheat, millet, sorghum, and corn (TCCP-funded research on soybeans was discontinued at the suggestion of AID); and legumes, tepary bean, moth bean, pigeon pea, cowpea, and dry bean.

For cereals, the procedure involves:

(1) Establish callus cultures.

(2) Screen for tolerance to NaCl (salt), $AlCl_3$ (aluminum), or PEG (ployethyleneglycol, MW-8000 drought).

(3) Regenerate plants from callus of selective and non-selective media.

(4) Transfer plants to soil, via greenhouse or growth chamber.

(5) Increase seeds.

(6) Evaluate for desired trait up to three generations in the field.

(7) Distribute tested seeds to plant breeders.

For legumes, the procedure involves:

(1) Establish callus and cells in liquid suspension culture.

(2) Screen for stress tolerance in vitro by culturing cells in nutrient solution containing NaCl, $AlCl_3$ or PEG.

(3) Regenerate plants.

(4) Transfer plants to soil.

(5) Obtain seeds of R_0 generation.

(6) Evaluate for desired trait up to three generations in the field.

(7) Distribute tested seed to plant breeders.

In 1986, the Cooperative Agreement was modified to provide an additional $200,000 and "special focus" in molecular biology and newer genetic procedures. The special focus covers areas such as genetic procedures for wide crosses by sexual means and cell fusion as well as genetic transformation combined with tissue culture procedures to produce stress-tolerant germplasm which normally cannot be obtained by standard procedures.

2. Networking

Establishing a network was one of the four "objectives" listed in the CA, "establish and expand a network of research institutions to share technologies, information and materials". The International Plant Biotechnology Network (IPBNet) was formed in 1985 to establish and foster working relationships

among scientists interested in using plant tissue culture to help accelerate the development of stress-tolerant crops in the developing world. It was established to facilitate the participation of researchers from developing countries, carry out collaborative research, and to "serve as a vehicle for exchange of information and germplasm, institution building, and technology transfer".

Participation in the network is of two categories: "equal partner" collaborators are selected from existing tissue culture laboratories active in stress tolerance and plant regeneration research. "General partners" are developing country institutions with interests in tissue culture and stress tolerance, but which do not have active programs in these fields. Priority for network services go to equal partner relationships; such services include training, graduate study, technical assistance, workshops, annual IPBNet conferences, a bi-annual newsletter, a computerized l terature system, and collaborative grants (subgrants) from TCCP. General members receive network information, can send staff to the training course, are invited to the annual conferences, and may apply for subgrants to carry out research of mutual interest thereby becoming equal partners.

Developing countries are selected for participation in IPBNet according to (1) interest in stress-tolerant crops, (2) technical readiness to participate, (3) willingness and ability

to contribute financially to training and networking on a partial matching basis, and (4) geographical location. Network members are responsible for free and rapid exchange of information with other members and obtaining partial funding for network participation. For training courses, network members are asked to meet transportation costs and normal salaries paid by the country concerned. The project supplies the remainder of the stipend required during training.

The network publishes a newsletter (five since IPBNet was established), a directory of IPBNet members and international funding resource list which will be updated annually, and periodic progress reports intended for the membership.

3. Training

One objective (output) of the proj ct is to provide plant tissue culture training to developing co ntry researchers to help meet crop production problems. The training program covers methodology for tissue culture research and laboratory techniques, set-up, and management. The six month course includes two months of formal instruction and four months of research, data analysis and preparation of a final report. The courses are held twice each year.

The course is conducted primarily by a full-time coordinator/instructor, assisted by a quarter-time instructor

and three guest lecturers. Topics covered include preparation of stock solutions, sterile techniques, cell culture, embryo culture, morphogenesis, in vitro selection for stress tolerance, media preparation, callus culture, meristem culture, anther culture, somatic embryogenesis, and virus indexing. Special topics covered in lectures or practical work include: molecular biology, statistics in tissue culture, germplasm preservation, set-up and management of tissue culture laboratory, and greenhouse practices for regeneration of plants from tissue culture. Each trainee selects a crop for study; generally this a food crop or crop of economic importance to his or her country. Trainees prepare a research proposal, carry out the research in the laboratory and greenhouse, analyze the data, and write up a research report which is then presented in a final seminar. Special diplomas are awarded by the project to each trainee completing the course, but no university credits are given. A brochure describing the course has be n prepared and distributed. Attractive and well laid out, i also includes an application blank and information about possible supplemental funding sources. Criteria for selection of candidates include: previous tissue culture experience; geographic distribution of applicants; position in home institution; availability of financial support; and crop of interest.

4. Technical Assistance

Technical assistance by the project has been mostly limited to assisting network members. TCCP personnel make periodic visits

to members working on subgrant research and provide assistance to their programs. Other laboratories and institutions may be visited during those trips, as well as USAIDs, and technical assistance, mostly in the form of advice, may be rendered. TCCP strengths in technical assistance are in regeneration, setting up and managing a tissue culture laboratory, and training.

B. Progress in Producing Results/Outputs

Findings

1. Stress Tolerance Selection Using Standard (i.e., somatic and callus) PTC procedures

The major output here involves the development of methodologies for improved mutant selection and plant regeneration. Techniques for obtaining long term plant regeneration from long term cultures capable of being used in *in vitro* selection experiments has been achieved for rice, millet and oats in 1984; for wheat in 1985; for corn and sorghum, and for tepary bean, moth bean, and pigeon pea this year. This represents very good progress.

Progress in developing techniques for selecting tissue cultures tolerant to enviornment stresses and regeneration of plants from stress-tolerant cell lines has, unfortur.tely, been less satisfactory to date. Techniques for NaCl, Al and PEG (polyethylene glycol) screening were adopted to obtain tolerant cell lines. However, planned heat tolerance screening was not achieved. The use of PEG as a selective agent for drought is questionable and probably should be dropped. Also, the use of NaCl as a selective agent for salt remains to be validated by rigorous field evaluations.

A third planned sub-output concerned the development of techniques for selecting tissue cultures and regenerated plants

from cell lines with altered biochemical traits. Techniques have not yet been developed. The current workplan indicates that activity is continuing until the end of the grant, but the team was informed during the discussions that this work has been discontinued, a decision in which the team agrees. Other institutions have already isolated and cloned the nitrate reductase genes.

The final sub-output is the development of techniques for obtaining high frequency plant regeneration from protoplasts of cereals. Regeneration from protoplasts of cereals has not been achieved. TCCP chose to work with indica rice which presents difficult problems. The project has not yet generated callus from indica rice, which has not been accomplished elsewhere, as has plant regeneration from japonica rice protoplasts.

The status of this research at the time of the evaluation is displayed, by crop and stress, in Exhibit No. 1. It is clear that the TCCP has made better than average progress in the development of plant regeneration techniques, but has made average or less than average progress in the other areas related to this output.

2. Stress Tolerance Selection Using a Broadened Genepool Through Molecular Biology and Tissue Culture (Special Focus)

The first SF (Special Focus) output is the development of and

application of methodologies to produce wide crosses and promote gene exchange. In using PTC to promote gene exchange in wide crosses of wheat, backcross plants have been obtained of wheat x alien species crosses is which alien chromosomes have introgressed in wheat chromosomes. Field evaluations must be carried out to determine if introgressed chromosomes carry resistance to karnal bunt or salt tolerance. Progress to date has been outstanding.

A second technique involves sexual crosses with alien species. A wide cross has been made between pigeon pea and Atylosia platacarpa and two out of fifteen excised embryos developed into fertile plants. Atylosia has resistance to Aschochyta blight. No evaluations of these putative hybrids has yet been made. If these prove to be true hybrids, this would be a very important TCCP accomplishment. Progress is above average. Such wido cross techniques, if perfected, could be very useful in broadening the genepool.

The second major output concerns developing techniques for obtaining hybrids by cell fusion. Cell cultures of Kallar grass (Leptochloa fusca) and basmati rice have been established. Cell cultures are intended for preparation of protoplasts. The work is collaborative with Pakistan and has been carried out by a visiting scientist.

The third SF output is the development of techniques using molecular biology and cell genetics for cloning of genes for stress traits and genetic transformation. In a collaborative effort, Dr. J. T. Colbert of CSU has been attempting the cloning of salt-stressed induced cDNA by isolating poly (A) RNA from salt-stressed and unstressed cells of kallar grass; then isolating single-stranded cDNA via hydroxyapatite column. The role of cloned cDNA in stress tolerance is to be verified by transforming salt-sensitive cells. No consistent SDS-PAGE yet observed in total proteins from salt-tolerant and sensitive cell cultures. Differences in mRNA, however, are expected.

While recognizing that the special focus activities were an add-on to the project and involve a small amount of resources, progress on the whole has been very good.

3. Verification, Seed Production and Distribution of Improved Cultivars

At the time of the evaluation, TCCP had conducted few field evaluation experiments to validate the research hypothesis (see Exhibit No 1). Oat lines from in vitro testing with NaCl solutions have been tested for two seasons in saline soil in Canada, sorghum lines from in vitro testing with NaCl solutions have been evaluated on acid soils in Georgia, and rice lines from similar testing with NaCl are being tested on saline soil in the Philippines. Several sorghum R lines appeared to be

tolerant to acid soils and one and two lines, respectively, seem to have resistance to fall army worm and midge, which can be a highly significant breakthrough outcome although an unplanned event.

Significant field testing could have begun as early as 1986, as urged by the Project Officer. In addition, there have been a number of defects in the field evaluation program conducted to date by TCCP which are discussed in the next chapter. Considering that field evaluations are the sine qua non of project success, performance to date has been poor to non-existent.

Exhibit No. 1

Status of TCCP Somaclonal Research*

crop and stress	in vitro callus/ sus. culture	in vitro stress test	in vitro plant regen.	field evals. generations 1	2	3	comments
Rice							
NaCl	x	x	x	x			R lines from NaCl tested on acid soil-CIAT
Al	x	x	x				
PEG	x	x	x				
Wheat							
NaCl	x	x	x				CIMMYT
Millet							
NaCl	x	x	x				R lines from NaCl tested for drought in Az-abandoned
Al	x	x	x				
Sorghum							
NaCl	x	x	x				R lines from NaCl observed in Ga on acid soil. Fall army worm & midge tolerance obs/d.
Al	x	x	x				
insect resist.	x	na	na	x			
Corn	x						
Oats							Field trials in Canada
NaCl	x	x	x	x	x		
Tepary bean							
NaCl	x	x	x				
Al	x	x	x				
Moth bean							
NaCl	x	x	x				
Pidg. bean							ICRISAT collaboration
NaCl	x	x	x				
Cowpea							no plans

4. IPBNet

Findings

Formation of the network in 1985 included visits by project personnel to 20 countries, the distribution of a survey-questionnaire to 400 potential collaborators in 38 countries, publication of the first IPBNet Newsletter, and an initial training course.

The first IPBNet Conference was held in Ft. Collins, Colorado, on October 21-25, 1985. Ninety-four persons from 21 countries took part, an auspicious beginning. The conference, devoted to exchange of information, featured tissue culture propagation of cereal crops. Workshops were held on somatic embryogenesis and plant regeneration, design and management of a tissue culture laboratory, isolation and manipulation of plant protoplasts, and selection of stress resistance in plant tissue culture. Planning workshops were devoted to questions concerning structure, purpose and objectives of the network. A list of participants was published in the IPBNet newsletter in July of the following year. Also included in this same newsletter were the Proceedings of the Conference, which consisted of brief abstracts of each paper delivered.

The Second Annual IPBNet Conference was held in Bangkok, Thailand, on January 11-16, 1987. Seventy-five persons from 18 countries attended and 31 papers and some two dozen papers were

presented. Abstracts presented at the Conference were published beforehand. Keynote talks were given on gene movement, rapid propagation, and anther culture. The agenda included feedback from members on ways the network could be improved. Requests included a directory of members and their interests, improved information retrieval, personnel exchanges, regional workshops and seminars, lists of potential funding agencies, a more international focus to the newsletter, reporting on member's research, and regional training.

The July 1987 Newsletter contained the first research reports from network members. It also included a survey form requesting information w.ich was subsequently used in a membership directory and funding source list published in 1988. IPBNet provides information services to its member from an information base consisting of 50,000 entries compiled since 1981 in 32 categories. The ervice provides individual literature s. arches by request; A BR. computer data base is used to access publications. The service also provides TCCP publications and reprints to network members. There have been 500 searches and reprint requests.

The Third IPBNet Conference is planned for January 8-12, 1989, in Nairobi, Kenya. One of the aims of the Conference will be to strengthen linkages and co.laboration with African scientists. A preliminary plan for the Conference was presented in the January 1988 Newsletter.

Performance

The performance of IBPNet has been up to or exceeded realistic expectations. Clearly, it has met a real need for information, training and research collaboration in tissue culture research. For example, each conference has been planned to build on past conference experience, and to improve and increase joint planning and collaboration among its members. IPBNet can be considered as moving steadily toward becoming a true, viable and collaborative research network. Its leadership has been responsive to the needs and requests of its members as is verified by the changes and improvements reflected in recent newsletters.

The team is impressed that coordination and support activity of the network is being provided effectively by a part-time TCCP employee. The publication of the IPBNet Directory for 1988, a very useful document, is also commended and the newsletters are well done and adequately distributed. The rate of publication for scientific papers is below that which might be expected for a project of this size. A weakness in the publications program, however, is the lack of actual and planned technical publications and guidelines for network members, particularly the targeted end-users of the methodologies being developed.

The inability or low priority afforded cooperation with other

U.S. universities in IPBNet is noted with regret. This has already been commented upon above in terms of the research being carried out. The team would also have liked to have seen more collaboration with the crop-oriented CRSPs and believes this desirable linkage should be emphasized in the remaining work covering the field trials, either in a collaborative or advisory mode. It is strongly suggested that TCCP renew its efforts to involve others in the remaining life of this project, both in an advisory capacity and as a partner in the field evaluations. In the later case, the AID project Officer should make every effort to assist TCCP management in obtaining CRSP cooperation.

The team concludes that the IPBNet focus (as in the project itself if additional funds were to be available) should be broadened from use of somaclonal variation to a wider array of methodologies in cell biology and aspects of molecular biology.

Within this framework, the team concludes that IPBNet needs to be continued and nurtured, irrespective of the eventual fate of TCCP. AID should continue to support IPBNet because it neatly fits its mandate a: helps developing countries, in a very cost-effective way, fin' ways to use plant biotechnology in crop improvement, without distorting necessary, on-going crop improvement research efforts. It is suggested that AID explore with CSU, network members and CGIAR, what the next steps in network evolution might be. The upcoming Nairobi Conference offers an outstanding opportunity for planing of IPBNet's

future. If sufficient progress is made on this question, this would be justification for supporting a fourth and final conference from TCCP funds for planning of collaborative programs and initiating ways of sustaining IPBNet over the long term.

5. Training

Findings

To date, 24 persons from 14 countries have completed the five courses given by TCCP. There is space in the training laboratory for seven trainees, so total capacity per year is a maximum of 14. Financial considerations have often limited enrollment to less than capacity. Two manuals have been prepared for the course. These are: Plant Tissue Culture Methods-A Laboratory Manual, compiled by S. Siriwardana, the Training Coordinator of TCCP, and A Handbook for Tissue Culture Laboratory Management Practices, compiled by S. Siriwardana and J. Hildreth. These anuals were published by the project.

TCCP collaborated with CATIE to put on the first regional tissue culture training program. The three-month course, conducted in Spanish, was based on the TCCP's training program. Twenty persons from eight countries in Central and South America took part.

TCCP has kept track of its former trainees. Of the 14 out of 24 who returned a recent questionnaire, it was learned that 80%

were currently involved in research, 14% in both research and teaching, and 6% in technical support. Areas of work are horticulture 21%, pathology 14%, tissue culture (direct) 21%. breeding 36%, and agronomy 8%. Of the techniques taught in the course, former trainees rated micropropagation as most important (78%). followed by in vitro selection (22%). Present sources of funding for former trainees were government 46%, government and international 15%, international 8%, other 23%, and none 8%. The major limitations were personnel, information, and materials. Several former trainees have conducted training for others in their home country; persons trained were Philippines 7, Zimbabwe 1, Pakistan 6, Indonesia 1, and Kenya 2, for a total of 17.

Performance

The training program, which was or should have been a secondary priority made possible because of the large in vitro research program, has been quite useful as a means for the involvemen of developing country officials and institutions in the project. Interest in the course apparently has been quite high, constrained mainly by the need to provide non-core financing for individual participants.

While this training has obviously been useful with some commendable achievements, particularly the preparation of training manuals, the establishment of specialized training facilities, and the first steps taken to stimulate and support

regional training, there have also been some problems. Of particular concern to the team were: the variable preparation of the trainees; the limited involvement of project senior scientists in the training; and the level of science in the training, including the appropriate balance between lectures, labs and practical work. It was also concerned about a possible overemphasis on somaclonal variation vis-a-vis other possibilities.

The team would like to see this course evaluated as an experience base to learn how training, as distinguished from education, in tissue culture and related techniques can be used more effectively to help developing countries get started and operating in such research.

The training course, along with the visiting scientist program, has been a v. tal part of IPBNet and, accordingly, mus. be one of the major a tivities to be considered in reference t continuation of the network after project completion. If team recommendations regarding the continuation and level of TCCP activities are accepted, it may be necessary to hold training to only one course a year. In any event, the team recommends that a CSU advisory team with external participation review the program and advise on its content, quality, focus, and possible future directions. This same group could also advise on the lessons to be gained so far in project and similar training.

6. Project Management

Findings

Requirements

Attachment B of the cooperative agreement (CA) sets forth an elaborate system for management covering, inter alia, procedures for selection and administration of subagreements, a description of anticipated tasks and outputs for each of the five years of the program, and a process for developing and approving the work plans involving review of an annual progress report, convening of an AID Advisory Panel, and formal approval of a mutually acceptable work plan - a process which was to be repeated annually.

The terms of the CA itself include additional requirements, many but not all of them related to financial management, and the "boilerplate" usually accompanying grants and contracts with the Federal Government in general and AID in particular. There is a special article on "Substantial Involvement Understandings" which states that "AID, through the Science and Technology Bureau, Office of Agriculture, will closely collaborate with the Recipient (CSU), monitoring program activities to establish specific research directions or redirections in response to research findings and in order to respond to interrelationships with other entities as these may evolve." Under Article V., Reports and Evaluation", further requirements are set forth with the intent of providing a management system appropriate for the expanded scope and greatly increased resources being made

available. This was to include a "University Contribution to the Program" for facilities, specifically: (1) a training facility for LDC personnel including a modern laboratory, tissue culture room and culture transfer facility; (2) a remodeled and expanded greenhouse; and (3) appropriate office space. Finally, it should be noted that $500,000 was earmarked for "Mission buy-ins" in anticipation of such requests.

In November 1984, at AID's suggestion, the TCCP hired a Development Management Consultant to advise them on establishing an operational workplan. The major portion of his time was spent developing a logframe usable as a framework for management with emphasis on creating specific outputs and suboutputs related to the project purpose, i.e., in terms of technologies developed and tested, with crops and specific stresses as the means. In the week spent on campus, the consultant, PI, and research staff developed the statement of major outputs and took the first one through the planning and scheduling of activities and milestones as a prototype. It was also to include a budget for each Grant Year and by outputs and suboutputs. This was an attempt to introduce a system of "management by objectives", i.e., by outputs or results. The completed product, but without cost estimates by suboutputs, was formally submitted to AID in March 1985 and approved. It was accompanied by an "Implementation Portfolio", prepared by a CPA management consultant.

During the above initial workplanning process, in the interest of economy, several advisory committees were eliminated or consolidated. This was to have some adverse effects but responsibility for management of the project was clarified by the creation of a Management Review Group (MRG) consisting of the PI, AID Project Officer and, subsequently, a representative from the Office of the Vice President for Research of CSU.

Staffing

Staff size doubled since August 1984, from 30 to 60 persons (20 to 32 full-time-equivalents) but there was a delay, paralleling the delay in preparation of the expanded facilities, in recruitment of senior management staff and some critical turnover. The current "management team" consists of the PI, an associate director, research coordinator, training coordinator, network coordinator, and an operations director. In addition, there are laboratory, greenhouse and office managers. Altogether, the current staff includes:

9 person management team

7 person research team

1 office assistant

11 graduate students

32 student research assistants

CSU Support

As part of its commitment to a joint effort in plant tissue culture, CSU supplied the facilities referred to before, estimated to have cost between $600,000 to $700,000.

Unfortunately, unforeseen delays in providing them caused a schedule slippage in the in vitro work.

According to senior CSU staff, a great deal of the overhead goes back to the project, directly or indirectly. Of the 55% which remains with the State or the University for the reimbursement of indirect costs, a portion of it is being used to amortize the remodeling and provision of new facilities. An additional 15% goes to the VP for Research for use on innovative and interdisciplinary research. The remaining 40% goes back to the College of Natural Sciences. Of this amount, approximately $500,000, 20% is retained and the balance is allotted to the Department of Biology (formerly Botany). The department uses these funds for administrative and other fixed costs and for hiring new staff, e.g., Dr. James Colbert in plant molecular biology.

As a result, at least partially, of AID's concern, in the fall of 1987 a TCCP/Advisory Group (internal) was formed to use on-campus expertise to advise the PI and to establish firm linkages with the CSU community. This group consists of Dr. James Colbert, Assistant Professor of Botany, Dr. Robert Heil, Director of CSU Experiment Station, Dr. Marvin Jensen, Director of the Irrigation Institute, Dr. James Meiman, Director of International Programs and the CSU representative on the MRG, Dr. John Raich, Dean of Natural Sciences, Dr. Lee Sommers, Chairman of Agronomy, and Dr. Stephen Wallner, Professor of

Horticulture.

The University was already involved in a comprehensive effort to increase its capabilities and role in biotechnology. Plant biotechnology was one of the five areas selected for emphasis with the greatest need in plant molecular biology. As a part of this effort, "affinity groups" which are problem-oriented are being used to provide the indispensable multi-disciplinary approach. One of the earliest groups established was in plant biotechnology, particularly "biotechnology for improved plant performance under stress", whose membership included Drs. Nabors, Gamborg, and Colbert.

AID Support

As was already mentioned, the Chief of S&T/AGR/RNR, Dr. Tejpal Gill, was concerned with management efficiency and effectiveness from the inception of this greatly expanded R&D and technology transfer effort. In June, 1987, a modification to the CA was processed which added an additi nal $200,000 for a special focus on wide crosses and gene exchange, cell fusion hybridization, and genetic transformation. When the Project Officer, Dr. James Walker, left AID in 1986, Dr. Gill assumed direct responsibility for the TCCP. In early 1987, he expressed concern with possilbe schedule slippages and the absence of usable monitoring and review information on project progress. This led to a series of meetings with TCCP and CSU senior management and, ultimately, to issue number 4 of this evaluation.

There have been no large mission buy-ins to date in this project but USAIDs have made small but very useful direct contributions in support of training, visiting scientists, graduate education and conference support. Given that the methodologies have not yet been tested and validated, it is neither surprising or alarming that more use of the buy-in earmark has not been made.

Progress

Management Effectiveness

It is obvious that the PI, and perhaps the AID Project Officer at the time, did not individually or jointly perceive much difference between operating under a contract vis-a-vis a cooperative agreement. It was not until Grant Year Three that the AID Project Officer began to complain, subtly at first, that he was not being involved in decision-making in a timely and effective fashion. It is unfortunate that it took several written and oral presentations to senior CSU officials before the TCCP management staff recognized that a real problem exisited. The PI was learning the art of "grantsmanship" the hard way.

Management, as distinct from administration, has been conducted largely on what appears to be an ad hoc basis. It was apparently not considered important or complicated enough to be included in the workplan, i.e., where activities were planned and resources allocated for it. The most glaring symptom of this condition was the poor quality of the annual progress reports

and the lateness with which they were submitted to AID. TCCPstaff had difficulty in distinguishing between reporting on research to their peers and network collaborators and reporting progress in producing the results expected to its grant partner, despite oral guidance given by the Project Officer. In part, this reflected some confusion by both parties on the purpose and intended audience of these reports and the situation was aggravated by a restricted concept of work planning. Despite early AID efforts to help TCCP adapt the illustrative workplan included in the CA to an output-oriented plan useful for day-to-day operations and management review, it apparently became a static document viewed by TCCP management as another bureaucratic requirement that had to be met. In effect, the project was being managed on a level-of-effort basis adjusted as circumstances required. The critical ending events sometimes got lost in the process.

With this type of reporting and workplanning, it is not surprising that difficulties were encountered in monitoring and reviewing progress. For example, The first work plan, covering Grant Year One, was not approved until March 1985. Because of delays in obtaining project facilities and new staff, this delay did not cause any serious problems. However, the workplan for Grant Year Two, Sep 85-Aug 86, was not submitted to AID in draft form until the summer of 1987, and then only after insistent AID reminders. Retroactive approval for GY 2 and 3 and approval of the current year was only given at an MRG meeting which took

place during this evaluation exercise on-campus, i.e., March 1988. For GY 2 and 3, this effectively eliminated AID from the decision-making process and constrained its contribution as to the direction of work in GY 4 and 5.

Staffing

Until the appointment of an Associate Director, no one other than the PI seemed concerned with relating day-to-day, bench level operations to output production and the achievement of the project purpose. By his own initiative, or by designation by the PI, Dr. Gamborg took an active interest in reporting and work planning which previously had been the responsibility of a young staff member with little prior management experience and none with AID or similar institutions.

Research Management

In attempting to assess research management performance, the team applied several criteria as follows:

(1) Clarity of objective(s) - While there was some confusion as to the project purpose, since approval of the first workplan in 1985, the outputs or expected results were reasonably clear. There was some confusion, however, as to the purpose or function of the project and a subsequent distortion of priorities.

(2) Shared expectations (including the quality, magnitude and type of outputs and subcategories thereof) - As discussed under R&D performance, studies and experiments were sometimes

inappropriately designed to produce data and results from which one could draw valid conclusions. The quality of the staff itself was uneven and not always qualified to handle some of the work, notably the field trials. Too often, the level and priority of work seemed more related to resources available, i.e., level of effort and trial and error experimentation. Notable exceptions involve the collaborative work carried out with CIMMYT, ICRISAT, and Pakistan. Expectations regarding TCCP research goals and the needs of TCCP staff (particularly graduate students from the LDC's) did not always mesh. This is a normal conflict when both education and programmed research are mixed; however, such difficulties can usually be overcome by careful planning and close monitoring. Unfortunately, the team was not afforded an opportunity to meet informally or socially with research staff or graduate students.

(3) Clear lines of responsibility/authority - Due to the delay in recruitment of senior research managerial staff, clear lines were not established early in the life of the project. This situation was aggravated by the lack of experience in field research and the failure to seek outside assistance. During the team discussions, it was noted that in their oral presentations, TCCP staff would sometimes say things regarding research status which was at odds with the documentation supplied, a symptom of confusion.

(4) Coordination of work - Since collaborative research involved discreet blocks of work, coordination with the TCCP lab usually was not an important factor, but the monitoring of

progress and quality control is. This aspect seems to have been carried out in an adequate fashion but coordination of the *in vitro* work with field trials was done on an *ad hoc* basis until a coordinator for field programs was appointed. Since the coordinator lacked field experience himself, the failure to seek outside assistance and/or advice on designing experiments and conducting field evaluations on a systematic basis was a serious oversight. There is however, still time to resolve this problem .

(5) Communication - The last, and perhaps more important, criteria is the quality of communication with the research sponsors, in this case AID and CSU itself. Clearly, this has been a major problem for all parties, as already described above.

Advisory Groups

In the first approved workplan, it was agreed that a MRG would be established and composed of CSU, AID, and others familiar with the administration of multi-natio al agricultural research programs supplemented, as necessary, with research and international networking specialists. It met during the first IPBNet Conference and proved to be unwieldly. It was not used effectively, i.e., as a joint decision-making mechanism for CSU and AID, until very recently when its membership was restricted to the PI, AID Project Officer, and a representative from the University, and its function was clarified with all parties.

In retrospect, it is indeed unfortunate that an external technical or research advisory commitee (TAC) was notestablished as originally intended but which was subsequently dropped as an economy move in the first workplan. As discussed elsewhere, this omission had a direct bearing on the quality and relevance of the research program. In terms of internal guidance, last year the Vice President of Research took the initiative in establishing a CSU/TCCP Advisory Committee which was a necessary and commendable action. It not only reflects the University's concern with some of the problems with this project raised by AID and perhaps others, but manifests CSU's recognition of plant tissue culture as part of its larger, interdisciplinary approach to plant biotechnology. Since this was an underlying justification for the grant, this development must be pleasing to all parties.

A problem did emerge with the Tissue Culture Research Grants Committee as CSU proposals for cooperative research (as distinguished from coll borative research to produce project outputs) overlapped those granted through the AID Science Adviser's Program. This was corrected during the first grant year by AID and communicated to CSU.

Sub-grants and buy-ins

The low use of subgrants to involve U.S. and LDC institutions in project research is a disappointment. TCCP staff complained that it was onerous and time-consuming to process a subgrant through the AID Contract Office and sought to overcome this by

the use of less formal "subagreements". It was one of the first activities dropped by the PI when economies seemed necessary, perhaps a reflex action to protect the research base on campus. This also appears to have been a mistake in judgement.

The low use of subgrants, or their equivalents, to involve others, combined with the absence of significant mission buy-ins, can be interpreted as an indicator of poor performance but, at least insofar as buy-ins are concerned, more likely it reflects overoptimistic expectations at the time of project justification and initiation.

Performance

While there have been some efforts made to improve research management in the past year and a half, the team has concluded that the poor quality of overall management has constrained the performance and quality of research and its products. Less than adequate management performance has been manifested in several ways, most notably:

- o poor reporting to AID;
- o static and untimely workplanning;
- o lack of sufficient emphasis on producing final outputs;
- o ineffective or late use of technical advisory groups to shore up weaknesses and/or lack of experience and avoid duplication, e.g., field testing, training, and design of experiments; and

o the apparent inability, at least in the first three critical grant years, of the Project Director (PI) to: (a) effectively involve AID in TCCP substantive decision-making; and (b) provide the technical and management leadership necessary to prove the research hypothesis and achieve the project purpose within the timeframe and resources provided, the utimate criterion of management effectiveness,

Less this judgement seem to be too harsh, it must be recognized that, first, some important remedial actions have already been instituted by CSU, AID and TCCP management, as discussed in more detail in the next chapter on issues, and second, that there is time to improve the planning, design, and control of field testing and evaluation, probably within the resources already available. The team believes the support provided to the TCCP by the Vice President for Research and college and department heads has been commendable and generous.

Both CSU and AID have taken strong actions within the last year to improve management effectiveness, the results of which remain to be seen but bode better for the remaining term of the project. The team also gained the impression that the PI recognizes the management mistakes and omissions of the past and understands his need for expert outside assistance and support and increasing the involvement of others in project activities, both within and external to CSU.

C. Overall Assessment

In an attempt to make its assessments as objective, consistent and accurate as possible, the team used a five point favor-to-disfavor scale to rate each sub-output and output. The results are displayed in Exhibit No. 2. A brief explanation of the assessment for each major component follows:

Research and Development

The project has progressed rapidly in obtaining information on cell culture, stress tolerance selection, and plant regeneration steps *in vitro* for cereals and grain legumes. This information could be useful for isolation and selection of somaclonal variants of food crops.

On the other hand, verification of stress tolerance under field conditions has been noticeably slow. One reason for this might be the attempt by TCCP to sustain high levels of regeneration from cultures held for a long time. Usually, the longer a culture is held, the higher the incidence of somaclonal variation. Whatever the reason, there has not been a sufficiently systematic approach to linking developments in the laboratory with field testing and validation of the research hypothesis. As a consequence field testing has been *ad hoc* in nature and opportunities for collaboration have been lost. For example, greenhouse studies were not appropriately conducted

to permit statistical analysis and adequate statistical designs have not yet been provided for field verification trials. Seed increases have not been adequately planned to expedite field testing and the use of off-season nurseries to speed up seed increase and to increase the number of testing seasons has not been adequately considered.

In brief, performance on *in vitro* research for somaclonal variation, while lacking a first-rate experimental design, has ranged from fair to very good and, overall, is satisfactory. Verification performance, or lack of it in most instances, however, has been poor and less than should be expected at this date.

The so-called "special focus" performance has ranged from as expected to, in the case of wheat wide crosses, excellent although there are some instances of duplication of the efforts of other institutions.

Networking and Training

Performance in networking, particularly in creating and sustaining IPBNet, met or exceeded realistic expectations. Only in the area of establishing working relations with other U. S. institutions have the results to date been somewhat disappointing. The training program has also been very good, although problems were encountered. Noteworthy was the first

regional training program in PTC put on by CATIE.

Management

Notwithstanding recent joint efforts at improvement, including strong CSU support, both project and research management performance has been less than should be reasonably expected and has constrained the quality and timeliness of research activity and its products.

EXHIBIT NO. 2

Summary of Performance Ratings

Explanation:

In arriving at its assessment of performance, the team used a structured frame of reference in an attempt to give a quantitative, albeit sometimes subjective, rating. This favor-to-disfavor scale was applied against each output and major subcategory thereof and averaged to provide the team's overall assessment. In the case of research per se, the ratings are objective, i.e., they reflect the actual reported performance as measured against the specified outputs or intended results.

A five point favor-to-disfavor scale was used as follows:

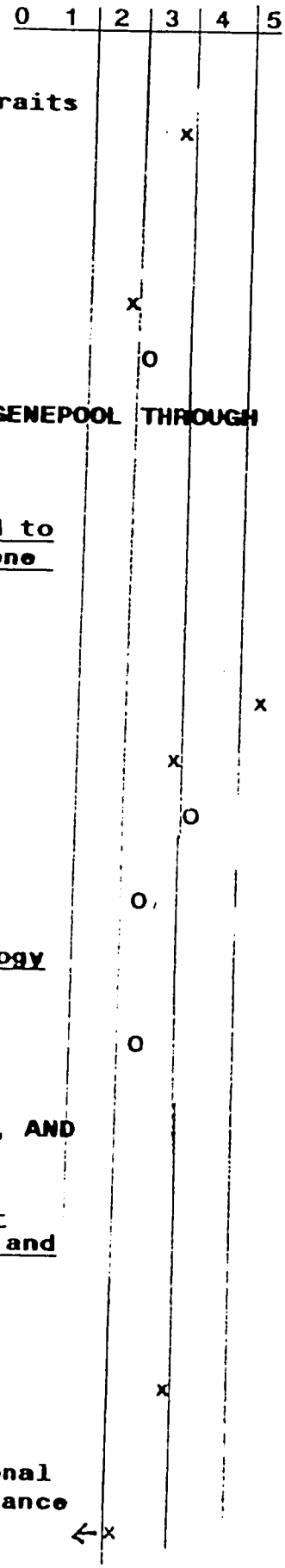
0 no progress
1 poor/very marginal
2 fair/less than expected
3 average/as expected
4 very good/more than expected
5 excellent/beyond reasonable expectations

Ratings

STRESS TOLERANCE SELECTION USING SOMATIC CELL AND CALLUS CULTURE PROCEDURES

Output 1. Methodologies develope for improved mutant selection and plant regeneration

	0	1	2	3	4	5
1a-Techniques for obtaining high-frequency, long-term, plant regeneration from cultures capable of being used in in vitro selection experiments					x	
1b-Techniques for selecting tissue cultures tolerant to environmental stresses and regeneration of plants from stress-tolerant cell lines			x			



1c-Techniques for selecting tissue cultures and regenerated plants from cell lines with altered biochemical traits

1d-Techniques for obtaining high-frequency plant regeneration from protoplasts of cereals

Output 1- Overall assessment

STRESS TOLERANCE SELECTION USING A BROADENED GENEPOOL THROUGH MOLECULAR BIOLOGY AND TISSUE CULTURE

Output SF1 Methodologies developed and applied to produce wide crosses and promote gene exchange

1a-Techniques for using tissue culture to promote gene exchange in wide crosses of wheat

1b-Sexual crosses with alien species

Output SF1- Overall assessment

Output SF2 Techniques for obtaining hybrids by cell fusion

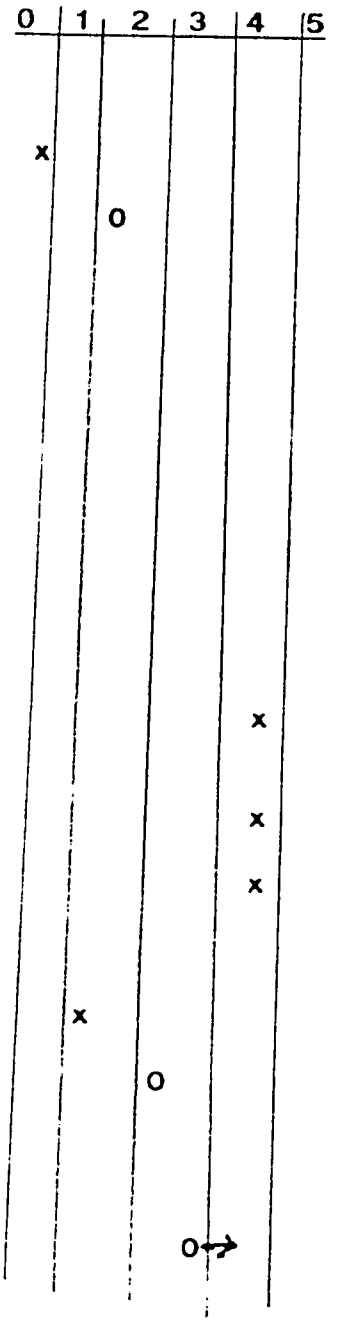
Output SF3 Techniques for using molecular biology and cell genetics for cloning of genes for stress traits and genetic transformation.

VERIFICATION, SEED PRODUCTION AND DISTRIBUTION, AND USE OF NEW CULTIVARS

Output 2 Verification of stress tolerance selection techniques through greenhouse and field testing

Output 2a-Greenhouse test results showing whether tissue culture techniques can give rise to stress-tolerant plants

Output 2b-Crop species field tested to determine extent tissue culture (somaclonal variation) regenerated plants show tolerance in the field



Output 2c-Seeds with increased field tolerance for one or more stresses made available to plant breeders

Output 2 - Overall assessment

INTERNATIONAL PLANT BIOTECHNOLOGY NETWORK

Output 3. Network expanded and support services provided to network participants, including information gathering and dissemination, conference preparation, technical assistance, personal exchange and subgrants

3a-Establish exchanges thru newsletters, reports, conferences and consulting

3b-At least 6 LDC collaborators involved

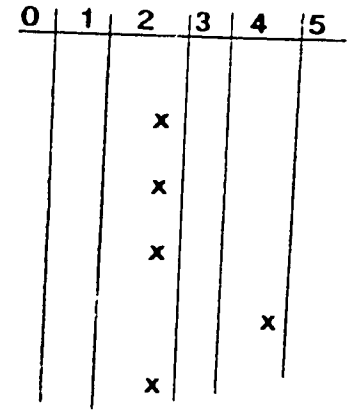
3c-At least 3 IARCs or CRSPs

3d-Collaboration with at least 3 North American universities or 1 CRSP in research, field testing

Output 3- Overall assessment

Output 4 Plant biotechnology training center established with capacity to train up to 14 scientists/technicians per year in plant tissue culture

Output 5 **Management**



III. FINDINGS AND CONCLUSIONS

A. Special Issues for Review

As part of its terms of reference , the team and TCCP were provided with four special issues to guide it to conceptual and operational problems of primary interest to AID and, presumably, CSU. The explanation and detail of the issues was included and sent to CSU in November with a request that the TCCP staff prepare preliminary written replies for distribution to the team and interested parties as soon as possible. CSU was also encouraged to revise its reply as it saw fit after the on-campus exercise was over but concluded that its original version was sufficient. Their reply is attached as Appendix No. 3. The reader who needs a complete understanding of the issues is referred to both of these documents before proceeding further. A discus ion of these issues follows focusing on information not ncluded elsewhere in this report:

1. Clarification of Purpose and Major Design Elements

Findings

In summary, this issue is concerned primarily with a clear articulation of the purpose of the project, a statement which describes the change which the project, implemented by a cooperative agreement between AID and CSU, is to bring about and how this change(es) can be measured by objectively verified end-of-project status (EOPS) indicators which signal the

successful completion of the TCCP.

It was suggested that the primary purpose of the cooperative agreement and the project could be succinctly stated as "to develop and demonstrate a proven technology to targeted end-users, i.e., plant breeders in the developing countries". In its written draft reply, TCCP quoted the nuerous statements of purpose, goals, and objectives which gave rise to the confusion noted but essentially agreed with the suggested restatement noting that "The TCCP arose out of the knowledge [when it became clear that useful variants could be selected in agriculturally-useful plants] and to validate the hypothesis that this developing technology (and other aspects of plant biotechnology) could be effectively used and transferred to help LDC's with their many agricultural problems and opportunities". The TCCP did not, however, either in its first revised work plan (dated March 1985) or in its reply to this issue, spell out the research hypothesis, per se.

The "Program Description" attached to the cooperative agreement did not reflect a clear application of the "logical framework" concept developed by AID and presumably still required and useful. This is not an unusual outcome when a project paper is revised several times to increase its justification and to respond to the comments of the many reviewing or clearance parties. The result can often be an over-ambitious project (in terms of the resources and time to be made available) and a

redundancy between the major design elements, i.e., goal, purpose, outputs, activities, and inputs, plus the measures of each, which (unless corrected early in the project's life) can have a serious impact on subsequent project management including monitoring, review, and evaluation.

This condition was partially rectified during the first year of the grant when TCCP, in collaboration with AID, developed clearer statements of project outputs, suboutputs, and the major activities required to produce them and created EOPS indicators. These were formally approved by AID through their inclusion in the first workplan, but the central thrust of the project still was not clarified with some resultant confusion between ends (results/outputs) and means (activities), and distorted priorities, e.g., highlighting networking and training in reporting to AID over proving the research hypothesis, the raison d'etre for the project. In the team's view, this condition was further compounded by the various and sometimes overlapping descriptions given to different components of the R&D program, e.g., implementing, pathbreaking, cooperative, collaborative, and, most recently, special focus.

Other deficiencies in the project design which still remain include: failure to distinguish between AID's development goals and CSU's insitutional goals; lack of specification on major tasks and beginning events (now a moot point); and more serious today, the dropping of milestones used for reporting and

monitoring, including the absence of recognizable and targeted ending events.

Conclusions

Not unexpectedly, CSU officials showed a tendency to revert to the original statements in the cooperative agreement to justify or defend its actions but an explanation of the logframe concept by the team leader and its application to the TCCP quickly resulted in agreement by all parties to a revised project purpose statement and research hypothesis plus a lament by the Principal Investigator (PI) that it had not been accomplished sooner. This agreement was facilitated by the reiteration that the cooperative agreement mechanism was chosen, inter alia, to provide institutional flexibility to both CSU and AID in reacting to unexpected events and breakthroughs by way of the annual progress reporting, monitoring and workplan revision process. As a result of an interactive blackboard exercise, the following schematic display of the redefined design elements or structure was developed:

Goals

AID - To increase food consumption in the less developed countries, improve the quality of life and income for the rural poor and marginal farmers, and improve and maintain natural resources. One program option or strategy to help achieve this goal is to change crop characteristics - in terms of lower input

and management needs - to fit the enviornment, e.g., to breed stress-tolerant cultivars.

CSU - To carry out its traditional land grant institutional mission; to develop and maintain an international dimension; and to expand its plant biotechnology capabilities.

Development hypothesis

Improved and expanded plant tissue culture methodologies can reduce the time and cost involved and increase the effectiveness (through creation of more desirable mutants) of breeding programs for stress-tolerance in the LDC's. [NOTE: This "higher level goal", or some similar statement thereof, becomes AID's justification and continuing rationale for funding the project.]

Purpose

[NOTE: To prevent confusion with outputs, sometimes referred to as objectives, and to the extent feasible, the statement should be confined to one purpose and, in this case, a purpose which is a shared concept of both AID and CSU.] To develop, demonstrate, and transfer validated methodologies for the regeneration and selection of stress-tolerant germplasma using a representative number of crops and stresses prevalent in the developing world.

Research hypothesis and project approach-The techniques of plant tissue culture, particularly the selection of somaclonal variants, can be used by plant breeders in a cost-effective manner to facilitate and enhance the improvement of certain important food crop plants by increasing their resistance to

selected edaphic, climatic, and biotic stresses limiting production. The project approach for the development, testing, and transfer of this technology to and for application in the LDC's will involve use of networking for collaborative research, training, and personnel and information exchange.

Results

[NOTE: Referred to as "outputs" in AID terminology, the project hypothesis is, in effect, that producing the planned outputs (including unexpected results) will in combination result in successful achievement of the project purpose. A more logical structure for these outputs is suggested as follows:

I. Research and Development

A. Stress tolerance selection using somatic cell and callus culture procedures

B. Stress tolerance selection through molecular biology and tissue culture procedures

C. Verification, Seed Production and Distribution

II. Technology Transfer

A. Network support

B. Training

C. Publications

D. Utilization

C. Technical assistance

III. Management

A. Reports

B. Workplans

C. Committees

D. Research

E. AID/CSU support

Recent and current efforts to improve the quality and usefulness of workplanning (see Issue No 4) are well on their way to correcting the "design" deficiencies noted in the original issue paper prepared by AID and should be continued, particularly using it as a management tool for research operations. Improving project design - at this point with the focus on suboutputs , milestones, ending events and EOPS indicators - should be viewed as a continuous process with changes approved formally in the annual revision of workplans.

The EOPS statements developed in the first workplan seem adequate for the revised "purpose" statement suggested but, after action is taken on the team recommendations, they should be reviewed again and perhaps revised at the next meeting of the MRG. They will be the basis for a terminal evaluation, if one is undertaken, a projection of impact, and the justification of follow-up action, if any. THEREFORE, THEY SHOULD NOT BE TAKEN LIGHTLY BY CSU OR AID.

Finally, it should be noted that the evaluation exercise, including the preparatory work accomplished by both parties, was

a major factor in being able to reach a consensus quickly on arevised statement of purpose. This was a critical event as it provided the evaluation team with a consistent criterion for the assessment of performance and progress and estimating the probability of project success.

2. Slow Rate of Progress

Findings

In this issue, AID stated its concern with the apparent slow rate of progress being made in the development of appropriate methodologies, in the field testing and demonstration of results, and the possible negative effects thereof on successful project completion by 1989, the grant termination date. Part of the problem was the lack of ending events and milestones which made the measurement of progress by AID very difficult and subjective. It was also difficul for the team which was forced to construct its own status chart.

The progress to date in research is fully described in Chapter II, as the team assesses it, and in Appendix No. 3 as perceived by CSU/TCCP. As already noted, progress has been satisfactory and reasonably on schedule for <u>in vitro</u> stress selection for somaclonal variation and in the "special focus" activities but has been much less than expected in verification of methodologies, a condition the team found very troublesome for a

number of reasons and requires some further analysis.

The basic assumption (research assumption) in the TCCP is that some somaclonal variants of plants that arise from tissue cultures will provide useful traits for crop improvement. Culturing of plant tissue results in abundant mutations has been published extensively. The proposed unique contribution of TCCP research was (a) to determine whether some somaclonal variants, caused by imposed but select stresses on the plant cells, had higher tolerance to corresponding edaphic, climatic, and biotic stresses and (b) to develop in vitro strategies for selecting callus cultures that were mutant for these stress tolerances. The success of both (a) and (b) must be validated by field testing progenies of regenerated plants from tissue cultures that survive selection. The field test conditions must include the stress for which in vitro selection occurred in order to evaluat the validity of both. AID was justified in being concorned

Conclusions

As already noted, the team believes that the TCCP has been exceedingly slow in conducting field experiments to evaluate whether some somaclonal variants are stress tolerant or whether in vitro selection was effective for detecting stress tolerant variants, the raison d'etre of the project. Furthermore, the team detected a number of defects in the field

evaluation program conducted to date by the TCCP:

(1) First generation ($R_{o.1}$) progenies of regenerated plants were sown on soils with stress which resulted in slow seed increase. $R_{o.1}$ lines should have been grown on non-stress soils to provide rapid seed increase before any attempt at evaluation.

(2) Progenies of regenerated sorghum plants from *in vitro* selection with NaCl were evaluated in acid soils and for insect tolerance in Georgia. Also, progenies of generated pearl millet plants from *in vitro* selection for NaCl were evaluated on droughty soils in Arizona. These do *not* provide appropriate validation for the *in vitro* selection.

(3) Field evaluation trials have not been conducted with appropriate statistical designs to permit valid data analyses. Evaluation experiments were not replicated and R (generation) lines were discarded each year as the evaluation proceeded.

hese instances give the impression that TCCP (a) did not understand the significance of field ve ification tests to the mission of the project, (b) conducted field evaluations on an *ad hoc* basis, (c) did not understand the importance of statistical control and inferences in summarizing data, and (4) had not, in fact, decided whether the purpose of the project was the "development of methodology" or the "development of germplasm".

At this point, it is clear to all parties that the TCCP needs to concentrate the remainder of its effort, resources, and life to

field evaluation studies. The team suggests that three years (equals three generations of field testing) is needed for validation of one species-selection regime combination. Because of its poor performance to date, the team also suggests that an external technical advisory committee group be organized to help TCCP plan and carry out field tests and germplasm activities. The group should consist of a plant breeder, soils expert, statistician, and germplasm expert.

To provide a timely and successful termination of the project, and in the context of the probable resources available, the team recommends that eight species-selection field trial combinations, denoted with asterisks in Exhibit No. 3, be chosen for field testing. With three years of testing for each of eight species-field trial combinations, 24 field experiments would be conducted. To date, only one recommended trial has been conducted, leaving 23 to go. With an estimate of 50 lines and checks per species-field trial combination and four replications per experiment, the 23 experiments yet to be conducted would require 4,600 plots. At an average cost of $60 per plot, the estimated cost for the field evaluation trails for the the remainder of the project would be $276,000. The field testing would be completed by 1991.

This plan for field testing of R lines should permit TCCP to determine which somaclonal variants with stress tolerance occurred in the tissue cultures, but it will <u>not</u> answer

whether *in vitro* selection was effective because the laboratory experiments were not appropriately designed to test this hypothesis. If stress tolerant somaclonal variants are found, it is imperative that these variants be multiplied, properly stored, and distributed for use in crop improvement. If one assumes that 20% of the lines being tested would have some proven degree of stress tolerance, 80 R lines would result. These would be called germplasm lines and should be increased to 50 kg of each. All lines should be registered with the Crop Science Society of America and 2kg samples of each should be stored in the National Seed Storage Laboratory at CSU. The 50kg seed lots of germplasm should be available one year after the validation experiments for a species-trial are completed. Availability of seed of the germplasm lines should be advertised in the TCCP Newsletter, and in international commodity newsletters. Someone will need to assume responsibility for germplasm distribution for several years after the project is completed, probably CSU. Cost of germplasm build up, preservation, and distribution is estimated at $80,000 (i.e., $1,000 per line).

To carry out the minimum field testing recommended by the team for validation of the research hypothesis, and in consideration of the current project status, it will be necessary to extend the project completion date for an additional two years, i.e., until August 31, 1991.

Exhibit No. 3

RECOMMENDED FIELD EVALUATIONS

Crop/Stress	Field Evaluations Generations 1	2	3	Method Validated (earliest possible date)	Comments
Rice					
NaCl	x	88	89	89*	PI & Pakistan
Al	88	89	90	90**	At CIAT
PEG					No plans
Wheat					
NaCl	89	90	91	91**	CIMMYT
Millet					
NaCL					No plans
Al					No plans
drought	88	89	90	90**	With NaCl & Al-stressed plants in AZ & KS
Sorghum					
NaCl	88	89	90	90**	No test plans per se
Al	88	89	90	90**	NaCl-tolerant plants tested for acid(high Al) in Ga.
insect resistence	x	88	89	89*	Test on NaCl-stressed plants with UGa
drought	88	89	90	91**	Test on NaCl-stressed plants in AZ, Niger
Corn					No TCCP plans
Oats	x	x	88	88	Trials in Saskatoon

Tepary bean					
NaCl	89	90	91	91	
Al	89	90	91	91	
Moth bean					
NaCl	89	90	91	91	
Pigeon pea					
NaCl	88	89	90	90**	ICRISAT
Cowpea					No plans
Dry Bean					No plans

* = afforded high priority by team members
** = afforded high priority but must be completed after scheduled project completion date of Aug. 31, 1989

3. Cost-effectiveness

Findings

This issue refers to the lack of sufficient information on the cost of producing outputs and sub-outputs and the activities which produce them. In their reply to this issue (Appendix No. 3), TCCP states that "The Cooperative Agreement has no directives which require the preparation of cost-analyses...which would require the services of a statistician". This is a good example of the miscommunication that has been taking place between CSU and AID on this project and was manifested in the great difficulty the team had, despite prior requests by AID, in securing data by sub-outputs, a task the team had to complete itself on site with the help of the Operations Director. The cause of this problem is discussed under "Management" and will not be repeated here except to note that the inability of TCCP to provide adequate and timely information of this type was a major factor in the team's low assessment of its management performance.

This section will be used to present and/or highlight some additional conclusions and provide the basis for team recommendations regarding the level of effort necessary, i.e., time and resources, to successfully complete the project (see Exhibit No.4 and also III.B.3.)

Research

The *in vitro* research has been reasonably successful but determining the effectiveness of the selection procedures developed will be difficult because of the lack of an adequate experimental design. With field testing only beginning, it is not possible at this time to determine the cost of specific techniques or to compare them with alternative procedures, a major function of the final field tests and evaluation. For this reason, among others, the team recommends that top priority be given to the planning and implementation of the field tests and evaluations.

Networking

The establishment and support of IPBNet has been accomplished in a very cost-effective manner. Network conferences have been carried out under their original budgets with most participants finding their own funding for travel and living expenses and conference fees have helped meet direct conference costs. The excellent attendance at both conferences and subsequnt events is a measure of the wisdom of this approach to cost-effectiveness.

The IPBNet newsletters, four to date, have been the most successful part of the publications program, along with a recently distributed directory. The quality of research papers published to date has been satisfactory but the bi-annual

progress reports are not very useful to the researcher and research protocols or technical publications have not yet been planned. The team suggests that technical publications be built into the verification phase and that the MRG determine the specific audience for TCCP research progress reports as distinguished from management reports to AID.

The team suggests that TTCP take the leadership in broadening the IPBNet focus to include a wider array of methodologies in cell biology and the more promising aspects of molecular biology, including more crops, to ensure its survival. It further suggests that ways be sought to nurture and continue IPBNet after project completion because it is a very cost-effective way to support the use of plant biotechnology in crop improvement without distorting necessary and on-going crop improvement research efforts. Finally, and also directly related to cost-effectiveness, strong efforts should be made to involve others, particularly U.S. universities (including RSPs), IARCs and NARCs in the remaining life of the project, both in an advisory capacity and as a partner in the field evaluations.

For these reasons, networking should receive full support through the remainder of TCCP life, including the addition of a fourth conference whose principal theme will be on ways and means to continue IPBNet.

Training

This has also been a very cost-effective function, conducted on a cost-sharing basis which places considerble responsibility for trainee support on their home institutions and/or governments. This approach is likely to result in better use of trained personnel on their return home.

This activity should also be continued through grant completion although it may be necessary to reduce course frequency to once a year if savings are needed to support field evaluations. In any event, the focus should be on the type of training needed in the future. For this reason, the team recommends that a CSU advisory committee with outside participation review the program and advise on its content, quality, focus and possible future directions.

4. Management Problems

In its explanation of this issue, AID stated that it "...is concerned that the TCCP is not yet being managed in a way that provides confidence that the grant purpose will be substantially and successfully achieved within the timeframe (5 years) and resources made available. The evaluation team was specifically asked to review existing or potential problems in workplanning, reporting, decision making in the collaborative mode, and in research and output-oriented management. All of these points

were discussed in our assessment of performance and will not be repeated here in detail. The reader is also referred to CSU's reply in Appendix No. 3.

Findings

The major findings, i.e., the requirements for management as set forth in the CA and modified by subsequent actions, are primarily the same as those included above under "Project Management". There is nothing of substance to add except to reiterate that a number of significant remedial actions have already been undertaken to correct management problems including:

- o the development of written guidelines on the preparation of reports intended for AID management, particularly the quarterly and annual progress reports;
- o provision of wr tten guidelines on the preparation and revision of annual wor plans, including allocating estimated expenditures by outputs and subcatergories thereof;
- o establishing an internal CSU technical advisory group for the TCCP; and,
- o redefining the functions and role of the MRG and reconstituting its membership .

These actions, most of which took place since the problem was raised formally by AID last October, removed much of the sting from this issue and TCCP staff, particularly the Project

Director, are commended for the mature and constructive attitude taken during this period in dealing with a sensitive matter both within CSU and in its relations with AID.

Conclusions

The team understands the concern expressed by AID. In the first place, as already stated just above on the slow rate of research progress, the field testing will not be completed by the end of GY-5 and certainly not within the programmed resources without severe culling of some of the in vitro activities. This condition was not evident in the documentation available before this evaluation exercise started. However, within the amount already obligated and still available, i.e., as the team understands it, up to $5,200,000 (not including $500,000 earmarked for mission buy-ins which, hopefully, could be used for field tests), and in consideration of the budget changes already suggested (see Exhibit No. 4), a two year unfunded extension of the cooperative agreement is feasible.

The value of management by objective was clearly demonstrated in this review. The usefulness of MOB in planning, reporting and monitoring also seems to be self-evident. Its importance, however, has not been recognized equally by all TCCP professional staff. We urge the staff to adopt the concept in daily practice for the remainder of project operations and commend it to the Vice President for Research for application to

other programmed research, including current and future AID projects.

Finally, it should be noted that in the beginning of this CA, the CSU administration played a passive role allowing the PI a completely free hand and was apparently not aware of when he needed help. When alerted by AID, however, it took rapid and effective action and its general support of the TCCP has been very good.

Specific suggestions include:

o By June, at the latest, TCCP should begin to draft the annual progress report to AID on GY-4 and in July, also at the latest, should begin revising the workplan for GY-5 and extending it to cover any subsequent year(s) which may be necessary and approved to complete the project. It should be an integrated process with the MRG involved to the maximum extent attainable. These tasks should be considered top priority and scheduled in the workplan as any other important project work.

o The workplan should contain meaningful milestones, including defined and targeted ending events, for use in reporting (both quarterly and annual progress/management reports to AID and CSU), monitoring and review.

o The TCCP should adopt, for its own internal use in

addition to reporting purposes, a management system based on outputs (results) and a budget and expenditure control system which provides data by tasks, major activities, sub-outputs, outputs and aggregations thereof (in addition to grant reporting requirements by objects of expenditure).

o As it would be uneconomic at this late stage to establish an external TAC, other than that recommended for field testing and evaluation, the CSU/TCCP Advisory Committee should take an active role in support of the project for the remainder of its life. Near the completion of this project, this committee may wish to review the results actually achieved and, in consideration of CSU's long-term and keen interest in plant biotechnology, recommend follow-on activities in the selection of stress tolerant cultivars applicable to developing countries.

o AID should work out a more efficient device (vis-vis sub-grants) for encouraging and financing collaborative research, particularly the critical field trials which will soon increase in frequency and importance. It is unrealistic to asssume that much of the cost of these trials will be picked up by the IARCs and USAID mission support for these trials should also be sought by the Project Officer.

o With improved management effectiveness and a decrease in labortory and greenhouse activities, there is an occasion to

review management responsibilities and reduce staff. The Project Director, or Associate Director, should assume direct responsibly for the field evaluations.

o At its next meeting, the MRG should provide the Project Director with written guidelines on the purpose, content, and format for TCCP research reports intended for external distribution as part of the TCCP publications program.

o Finally, and most important, it is imperative that the cooperative agreement term be extended to August 31, 1991, to permit completing of the minimum number of field tests and evaluations nesessary for accomplishing the project purpose. This extension should be conditioned on the agreement of CSU to effectively use both external and internal advisory groups to assist TCCP in designing the field experiments and conducting their evaluation.

Exhibit No. 4

Suggested Level of Effort by Outputs

For Remainder of Project Life

STRESS TOLERANCE SELECTION USING SOMATIC CELL AND CALLUS CULTURE PROCEDURES

Output 1 Methodologies developed for improved mutant selection and plant regeneration - reduce or eliminate

STRESS TOLERANCE SELECTION USING A BROADENED GENEPOOL THROUGH MOLECULAR BIOLOGY AND TISSUE CULTURE

Output SF1 Methodologies developed and applied to produce wide crosses and promote gene exchange - continue full support

Output SF2 Techniques for obtaining hybrids by cell fusion - continue support but elilminate cDNA cloning study

Output SF3 Techniques for using molecular biology and cell genetics for cloning of genes for stress traits and genetic transformation - continue support but eliminate cDNA cloning study

VERIFICATION, SEED PRODUCTION AND DISTRIBUTION, AND USE OF NEW CULTIVARS

Output 2 Verification of stress tolerance selection techniques through greenhouse and field testing - top priority through GY 7(need revised workplan)

INTERNATIONAL PLANT BIOTECHNOLOGY NETWORK

Output 3 Network expanded and support services provided including information gathering and dissemination, conference preparation, technical assistance, personal exchange and subgrants - continue full support through GY 7 (add 4th conference, involve IARCs and NARCs in field testing and evaluation using subgrants if necessary, begin technical publications program)

Output 4 Plant biotechnology training center established with capacity to train up to 14 scientists/technicians per year in plant

tissue cullture - conduct evaluation, continue but reduce frequencyif necessary MANAGEMENT

Output 5 Establish an output for management and include planned activities and budget in workplan, e.g., cost of external technical advisory committee for field evaluations, MRG meetings, etc.

B. Project Logic

1. Current Validity of Development Hypothesis

The development hypothesis or justification of the project, as agreed to by the evaluation participants (refer to Special Issue 1) is succinctly stated as - to increase food consumpstion in the less developed countries, improve the quality of life and income for the rural poor and marginal farmers, and improve and maintain natural resources by, among other things, breeding stress tolerant cultivars. Changing crop characteristics to fit the enviornment, rather than the other way around, was and still is a valid strategy as evidenced by the many improvements made in LDC agriculture by the application of new technologies developed through research, e.g., new, robust and productive crop varieties and new management practices for crop and soil manag ment.

2. Current Validity of Research Hypothesis and Project Approach

Not clearly stated in the original documentation, the research hypothesis can be stated somewhat along these lines, i.e., the techniques of plant tissue culture, specifically the selection of somaclonal variants caused by imposed but select stresses on plant cells, can be used by plant breeders to facilitate and enhance the improvement of important food crop plants by

increasing their resistance to important soil stresses and other factors limiting production. The project approach assumed that the development and transfer of this technology would be facilitated by use of a networking approach involving collaborative research, training, and personal and information exchange.

The validity of the research hypothesis must be judged against a very simple but determining question; can or does plant phenotypic or genotypic variation brought about by selection in vitro for certain plant stresses result in a greater level or type of useful tolerance than that available in existing genepools? Because of the lack of trial results, including some deficiencies in the design of in vitro experiments, the team cannot unequivocally state that this project will answer the question of potential usefulness of somaclonal variation for eveloping countries.

Success of the TCCP approach will ultimately be judged on the value of the technology developed and the germplasm made available to plant breeders in developing and developed countries of the world. Notwithstanding, even the development of one or two stress-tolerant cultivars of crops important to the developing world, an event quite possible in the TCCP, will fully justify AID's investment, not to mention the other project achievements and the new knowledge gained in PTC.

3. Probability of Successful Project Completion

Accepting the completion of field evaluations as the final ending event necessary and feasible for successful completion of the project purpose, viz, "To develop, demonstrate, and transfer a proven methodology for the regeneration and selection of stress tolerant germplasm of a representative number of crops and stresses prevalent in the developing world", the project will not be successfully completed by August 31, 1988, the end of its current term. As specified elsewhere in its conclusions and recommendations, the team believes it will take until 1991 (Grant Year 7) before a minimum number of field trials can be completed and evaluated.

C. Assessment of Effectiveness and Impact

Defining "effectiveness" as the degree of project success, i.e., the achievement of the project purpose which is specified as developing, demonstrating, and transferring validated technologies for the regeneration and selection of stress-tolerant germplasma, the team assesses the probability of success, based on the progress to date, as good or as expected. This does not take into consideration the probable valuable development or several stress-tolerant important cultivars as a by-product of developing the procedures and techniques.

Defining "impact" as the successful use by the end-users (plant

breeders) of the technologies developed to breed stress-tolerant crops in the developing world, the team is not sanguine that somaclonal variation techniques by themselves will have much more than limited use in improving crops". The technologies being developed, however, particularly in plant regeneration and in wide crosses, will certainly provide valuable new tools for the plant breeders. It should be noted that micropropagation of various species of plants in the LDCs on a commercial scale has occurred during the last few years. There has also been a multiplication of tissue culture labs in the LDCs.

IV. SUGGESTIONS AND RECOMMENDED ACTIONS

In its term of reference, the team was "...requested to review the project logic, including the development and research hypotheses, in the light of progress to date, new advances in biotechnology, and the current relevance of the major expected results to AID agriculture development priorities and programs." This has been done in Chapters II and III above.

The team was also requested to prepare appropriate recommendations. Throughout the report, a number of suggestions and recommendations, of varying importance and detail, have been presented which are intended to facilitate and expedite successful project completion and its ultimate impact within the team's understanding of the operating constraints of both AID and CSU. It is understood that both AID and CSU will review these actionable recommendations, first through their own individual internal processes, and then jointly, probably through the mechanism of the MRG, and either accept, modify, or reject them. To facilitate such review and subsequent decision-making, the recommendations are grouped by major project component where possible. Each recommendation will be followed, in parenthesis, with the suggested action agent. Where more than one is concerned, the first organization listed should initiate the action.

The team recommendations, abbreviated and/or combined as

appropriate, are:

Research

Verification

1. Action be taken at the earliest possible moment and top priority be given to plan and complete the critical mass of field trials and evaluations necessary to validate the implied research hypothesis and achieve the project purpose. This should involve, inter alia:

a. The redesign of field studies to cover three generation (three years) for the validation of one species-selection regime combination. Standard symbols should be adopted corresponding to those used by plant breeders; (TCCP)

b. Evaluations conducted for eight species-stress combinations (see Exhibit No. 3 for detail); (MRG, TCCP)

c. Organizing an external technical advisory committee (TAC) to help TCCP plan and carry-out fields tests and germplasm activities; (CSU, MRG)

d. Assuming stress-tolerant somaclonal variants will be found, these variants must be multiplied, properly stored, and distributed for use in crop improvement and the work plan should be revised/extended to cover such activities; (TCCP, MRG)

e. Such germplasm lines should be increased to 50 kg and registered with the Crop Science Society of America and 2 kg samples of each should be stored in the National Seed Storage

Laboratory at CSU; (TCCP, CSU) and

f. CSU assume responsibility for germplasm storage and distribution after project completion. (CSU)

Why?

In Vitro

2. To the extent feasible, and in order to conserve funds for field trials, in vitro activities for improved mutant selection and plant regeneration should be eliminated or curtailed. (TCCP, MRG)

3. Provision should be made by CSU for the adequate storage and protection of greenhouse seed produced to date.

Molecular Biology and Gene Transfer

4. Current modestly funded work plans for "special focus" activities should be continued, except for the cDNA cloning study. Consideration should be given to extending Dr. Colbert's work on wide crosses. (CSU, MRG)

which one?

Management

5. Research management, and particularly that of CSU and TCCP senior management, should concentrate on designing, scheduling, seeking collaborating partners, facilitating, and monitoring field trials and evaluations. This can include:

 Site Collection Sheets

a. Preparing detailed workplans for each species-stress combination; (TCCP, MRG)

b. Developing, publishing, and using (1) specified "milestone events" (e.g., for field tests, R_1, R_2, R_3 tests lines) and (2) "ending events" which are descriptive of the result wanted (e.g., in greenhouse growouts for plant regenerations, 25 plants in greenhouse, x gs. of fresh weight of callus or seed increase of x weight), for use in monitoring and reporting; (TCCP, MRG)

c. The specific audience(s) for TCCP research progress reports be determined and reporting guidelines developed accordingly <u>if</u> such reports are deemed cost-effective vis-a-vis other publications; (MRG)

d. The publication and distribution, built into the verification phase and covering <u>in vitro</u>, greenhouse and field testing, of research protocals/technical bulletins on proven methodologies; (TCCP, MRG) and

e. Making effective use of the proposed external technical advisory committee. (TCCP)

B. <u>Networking and Training</u>

6. The IPBNet should be nurtured and supported to the maximum extent possible. Such actions might include:

a. Broadening IPBNet's focus to include a wider array of methodologies in cell biology and the more promising aspects of

molecular biology, including more crops; (TCCP)

b. Network support, including a fourth IPBNet conference, be continued to project completion. Plans for the continuance of IPBNet after TCCP termination, in consultation with the CGIAR and network members, should be high on the agenda for the next conference and the major focus for the fourth and last conference supported with TCCP funding; (TCCP, MRG)

c. Strong efforts should be made to involve others, particularly U.S. institutions (including at least one CRSP), IARCs and NARCs in the remaining life of the project, both as a partner in field evaluations and in an advisory capacity. (TCCP, AID, CSU)

7. Training should be continued, on a reduced basis if necessary, through grant termination, but a CSU advisory team with external participation should review the program in terms of its content, focus, quality and possible future directions. (MRG)

Management

8. A number of management improvements have already been instituted and need to be sustained and monitored. The value of a management system based on results (outputs) has been demonstrated and the concept should be adopted by TCCP staff as a daily, operational practice for the remainder of the project. (TCCP)

9. In fact, the team commends the management-by-result system

to the Vice President for Research for application to other programmed research activities, including current and future development projects financed by AID and other donors. (CSU)

10. The preparation of the annual TCCP progress report to AID, the annual review of progress by the MRG, and the annual extension/revision and approval of the workplan should be an integrated process with maximum involvement of the MRG, beginning immediately. (TCCP, MRG)

11. The workplan should include management as a major component with scheduled activities and allocated resources. Defined milestones and ending events (see Recommendation 5.b. above) are a sine qua non and should be used in quarterly and annual reporting to AID and CSU. EOPS should be reviewed for adequacy. (TCCP, MRG)

12. The CSU/TCCP Advisory Committee should continue an active role in support of the project for the remainder of its life. As project completion nears, this committee may wish to review the results achieved and, in consideration of CSU's long-term and keen interest in plant biotechnology, recommend follow-on activities in the selection of stress-tolerant cultivars applicable to the developing countries and the United States. (CSU)

13. Based on decisions made as a result of the evaluation exercise, the next meeting of the MRG should be the occasion to review management responsibilities and priorities and staff changes and reductions. Either the Project Director, or his Associate, should assume direct responsibility for the field

evaluations. (MRG)

14. AID should work out a more effective device (vis-a-vis sub-grants) for encouraging and financing collaborative research, particularly for the critical field trials which will soon increase in frequency and importance. S&T/AGR should work with the AID Regional Bureaus in assisting TCCP, as necessary, in establishing such field linkages. (AID)

15. Finally, and most important, IT IS IMPERATIVE THAT THE COOPERATIVE AGREEMENT BETWEEN AID AND CSU BE EXTENDED TO AUGUST 31, 1991, to permit completing the minimum number of field tests and evaluations necessary for accomplishing the project purpose. This extension should be conditioned on the agreement of CSU and TCCP management to effective use of an external advisory group to assist TCCP in the design and conducting of field trials and the evaluation of their results. (AID, CSU)

APPENDIX 1

EVALUATION; ACCOUNTABILITY AND MANAGEMENT

Introductory Remarks

by Raymond E. Kitchell, Team Leader

External Evaluation

Tissue Culture Crops Project1

Accountability

Evaluation, whether we realize it or not, is increasingly becoming a way of life. In our competitive and complicated society, others are constantly evaluating us - on a personal and/or performance basis - and we are continually engaged in self-evaluation, or we should be. Individuals, families, businesses, nations, and even universities are forced to engage in the process if not for survival than to maximize the options as goals, assumptions and circumstances change.

In the private sector, at least in theory, there is a single, objective criteria of success or failure, i. e., the "bottom line", the profit and loss statement. But even there, its application is not so simple as many large corporations have found out to their dismay - and which goal becomes the most important, profit or long term growth and survival? How do you judge the cost-effectiveness of an R&D program? How do the so-called "non-profits" apply it? If it is a family company, it is responsible to no one else; as a public company it is, of

1 Presented at CSU on February 29,1988.

course, responsible to its stockholders who are readily identifiable.

In the public sector, the sector that both CSU and AID are involved, there are some common problems in evaluation shared with the private sector, e.g., defining missions and long-range goals, projecting changes in the operational enviornment, etc, but there are important and fundamental differences. To begin with, there is accountability by law. While sometimes this can be as vague as the "bottom line" concept, as Admiral Poindexter and Col. North will no doubt testify, it can have real consequences for public service managers, employees, and their contractors. What make. accountability so different in government is not just the consequences, i.e, loss of job versus going to jail, but how accountability is defined and to whom. In a democratic and plurisic society such as ours, one man's accountability may be anot er's treason.

Whether it is enlightened thinking in this modern age or just a reflex action which is the results of pennypinching and distrust of government, there are very specific U.S. Government requirements for monitoring and evaluation of government funded activities. Of specific relevance to this exercise, the Foreign Assistance Act of 1961 requires the Agency to follow accepted management practices in employing information systems and analytical techniques to support decision-making and the effectiveness of development assistance. In addition, Circular

117 of the Office of Management and Budget (it used to be called the Bureau of the Budget when I was working there specializing in agency planning and program and project management) requires that AID assess the efficiency and effectiveness of of development programs on a continuing basis. In short, AID is required by law and Government management standards to monitor and evaluate the use and results of development assistance to ensure that public funds are used as effectively as possible.

Management

The point I wish to make here is that, while as citizens and taxpayers, we can all understand why public officials, at the political and the administration level, must be held accountable for the use of public funds, in the public service evaluation is almost equally important as a mechanism for making decisions on programs which are d signed to meet new problems, both domestic and internati nal, which are innovative and non-repetitive in character, which explore new frontiers, and can be exceedingly expensive.

AID has been designing, monitoring, and evaluating development projects for a long time now but that was not always the case as I can personally testify. Even with its noteworthy and sometimes pathbreaking experience, the process sometimes becomes routine and more of a bureaucratic requirement than an exercise useful to the donors, the implementing agent, or the host

country. Also, almost from its inception, AID's process has concentrated on field projects involving technical or capital assistance. As the first evaluation officer of the Technical Assistance Bureau, predecesssor to the Bureau for Science and and Technology, I can tell you that the Agency system was not designed for application to R&D projects, institutional grants, or other centrally-administered programs. To get recognition of this difference was not easy and, of course, there were those in the TAB who claimed that it was impossible to evaluate R&D projects. Nevertheless, we developed a system which works - when properly applied. It begins, as with most projects, with a good project design. As the old saying goes, you can't tell when you get there if you don't know where you're going. (On the other hand, we are sometimes caught in the "catch 22" syndrome of trying to measure achievements based on a proposal inflated for justification purposes.) In a research project, this usually means specifying the research hypothesis. The second requirement is to prepare for the evaluation. Primarily, this means drafting a precise terms of reference for the evaluation team in which the purpose of the exercise is made clear and the important concerns or issues are identified. This step has the added advantages of (1) determining the type of information and data that will be necessary, (2) permitting the implementing agent to prepare itself, i.e., no surprises, and (3) providing guidance as to the optimum composition of the team. The third requirement, obviously, is to assemble a good team, a sine qua non. Finally, it is always helpful if the team leader has had

some prior experience in evaluation as distinguished from peer review.

The TCCP Evaluation

Now we come to the issue at hand, the mid-term, external evaluation of the TCCP, a collaborative endeavor between Colorado State University and the United States Agency for International Development. I think that the criteria for a successful evaluation as set forth just above have been met. The University, and particulary the TCCP staff, have made a very professional attempt to provide the information necessary for the team to reach sound conclusions and prepare realistic and actionable recommendations. AID, particularly, the Division of Renewable Natural Resources of the Office of Agriculture, S&T, and CSU, particularly the Department of Biology, are vitally concerned with the results and my colleagues and myself recognize the importance of our assig ment

Finally, a few words about how we will conduct the exercise. Today's proceedings are in the hands of the Principal Investigator and CSU officials. They have been invited to make any presentation they feel will effectively supplement the written documentation supplied, including a visit to labortory and greenhouse facilities. Starting tomorrow, I will chair the sessions, expected to take two full days, in which we will discuss the predetermined issues with TCCP staff and University

officials. These sessions will be open and observers are welcome. On Thursday, the team will go into closed sessions to begin developing its consensus and drafting its report. We may request some follow-up meetings with specific individuals and/or supplemental data. When we leave on Friday afternoon, I feel certain we will have reached agreement on all issues. However, and this is important to note, the process of putting these conclusions in writing, pulling them all together and seeing their implications is often a vital part of the synthesis. For this reason, before its departure, the Team will not give a preliminary briefing on its findings. However, with the cooperation of my colleagues, I will do my best to have the final version of the team report to both AID and CSU within a month. At that point, both parties can begin their internal review leading to a meeting of the Managament Review Group and subsequent action. Thank you.

Participants in TCCP External Evaluation

James Colbert	Assistant Professor	CSU
Joel Cohen	Biotechnology Adviser	AID/S&T/AGR
Ronny Duncan	Plant Breeder	Univ. of Georgia
Oluf Gamborg	Associate Director	TCCP
Dely Gapasin	Deputy Executive Director for Research	PCARRD
Tejal Gill	Project Officer*	AID/S&T/AGR/RNR
Gary Hanning	Research Coordinataor	TCCP
Judson Harper	Vice President for Research	CSU
Jack Hautaluoma	Associate Dean, College of Natural Sciences	CSU
Julie Ketchum	Operations Director	TCCP
James Meiman	Director, International Programs*	CSU
A. Mujeeb-Kazi	Visiting Scientist	CIMMYT
Murray Nabors	Project Director(PI)*	TCCP
John Raich	Dean, College of Natural Sciences	CSU
Sunitha Siriwardana	Training Coordinator	TCCP
Kerri Wright	Network Coorinator	TCCP
Bruce Wunder	Chairman, Biology Dep't.	CSU

---

* Member of Management Review Group (MRG)

CSU Reply to Evaluation Issues

EXECUTIVE SUMMARY OF THE ISSUES

ISSUE I. NEED FOR CLARIFICATION OF PURPOSE

A. There appears to be some confusion in design levels, e.g., the AID development/program goal or problem to which the Project is designed to impact and the specific purpose or objectives of the grant itself which can be measured by recognizable and finite end-of-project status indicators (EOPS). Does this require redefinition or clarification?

In general, the purpose of the Cooperative Agreement is to increase the ability of developing countries to feed themselves and others by producing and transferring to them useful techniques of plant biotechnology. The ability of developing countries to successfully utilize these techniques is also to be increased. The extent to which this purpose is achieved will be adequately measured by existing End-Of-Project-Status (EOPS) Indicators, although the existing indicators should be outlined in more detail.

B. It can be succinctly stated that the primary purpose of the Cooperative Agreement is to develop and demonstrate a proven technology to targeted end-users, i.e., LDC's and plant breeders. Is this purpose clearly understood and accepted by the principal participants?

This purpose is clearly understood by AID and by the TCCP.

C. What is the overall research hypothesis which needs verification and how will this be accomplished within the resources and time frame provide in the existing agreement? Is this adequately reflected in the EOPS indicators?

The overall research hypothesis is that plant tissue culture techniques can be used by plant breeders to increase the speed with which useful new cultivars are introduced to farmers and plant breeders in developing countries.

Verification of this hypothesis will be accomplished within the resources and time available, and this is adequately reflected in the EOPS Indicators.

D. In the remaining term of the Project, how much level of effort should be on plant protoplast and molecular biology to isolate and transfer the genes for stress tolerance traits? How would this change the EOPS indicators and/or time frame, if at all?

The existing modified Workplan of 1987 adequately portrays the current level of effort on plant protoplasts and molecular biology. Research on protoplasts should continue at the present rate. Molecular biology was funded only for two years (8/86-8/88) as an addition to the original Cooperative Agreement. Both the length and level of funding should be increased.

ISSUE 2: SLOW RATE OF RESEARCH PROGRESS AND POSSIBLE NEGATIVE EFFECTS ON SUCCESSFUL PROJECT COMPLETION BY 1989.

AID is concerned that insufficient progress has been made in the development of appropriate methodology and in the field testing and demonstration of results.

A. Given the baseline established in technology development at CSU before execution of the cooperative agreement (through AID and other support), for what sub-outputs has progress been less or more than should be expected? How does this progress or lack thereof affect (i) development of methodology; (ii) developing specific stress tolerance for selected crops; and (iii) demonstrating and gaining acceptance of results by targeted end-users?

In general the Project is on schedule in terms of achieving outputs. The overall goals and objectives of the Project have been or will be achieved as envisioned at the start of the Project.

B. How much research has been assigned to collaborating institutions and how well is it planned, facilitated, and monitored by TCCP?

Research directly relating to Project outputs has been assigned to CIMMYT, the University of the Philippines at Los Baños, Visayas State College of Agriculture, Louisiana State University, and the University of Georgia. This research is well planned, facilitated, and monitored by the TCCP through the implementation of Cooperative Agreements and site visits.

C. Given the current inadequant, state-of-the-art in plant regeneration from protoplast and cell suspension culture of cereals and legumes and the technologies for the "identification of genes controlling resistance to stress and our ability to isolate and move them", is it realistic to presume that output can be accomplished by 1989?

The TCCP continues to be a pioneer in the development of plant regeneration techniques from suspensions and protoplasts of legumes and cereals. Projected outputs will be achieved on schedule. Work on molecular biology is supported for two years (8/86-8/88) at a level of $100,000 per year. Again, projected outputs will be achieved on schedule with respect to molecular biology. The outputs relate to technique development in both cases and do not specify crops, numbers of plants, or transfer of developing technology to specified users.

D. On what basis were the "Project objecti es" expanded in 1986 to include molecular biology? What are the budgetary and scheduling ramifications of such an expansion of project outputs? Where is the expected output described?

AID asked CSU to expand the Workplan and Budget in 1986 to include a "special focus) on molecular biology. The emphasis is on developing techniques to move genes for stress tolerance from wild to cultivated species.

E. How adequate and/or standard is or should be the research methodology being used and/or planned for the field testing of stress-tolerant cultures and validation of TCCP developed tissue culture methodologies? Reporting to date

does not seem to indicate that the Project network (IPBNET) is as yet effectively involved in the field testing, validation and demonstration aspects.

TCCP is currently field testing over 6,000 lines of regenerated plants of five species in five countries at ten field locations. A standardized methodology of collaborations and testing is utilized as best described in the Annual Report of 1987.

ISSUE 3. LACK OF SUFFICIENT INFORMATION ON THE COST OF PRODUCING OUTPUTS AND SUBOUTPUTS.

Despite AID requirements, CSU has not provided information which will permit a cost-effectiveness analysis to determine Project options or priorities given resource and scheduling constraints.

The Cooperative Agreement has no directives which require the preparation of cost-effectiveness analyses. A thorough analysis would best be carried out by a statistician. The following information represents the TCCP Management's best efforts toward providing the information requested.

A. Compare the results of annual IPBNet conferences with expectations, costs, and alternatives.

IPBNet Conferences were scheduled every other year instead of every year as originally planned. In both cases substantial numbers of participants from developing countries attended, and costs were well under budget for each year. The first conference was held in Fort Collins, and the second in Bangkok. The third conference is planned for Nairobi. The benefits of holding conference in developing countries are high in terms of both low costs and numbers of people who can attend.

B. Compare the cost of TCCP support of graduate students with their contribution to producing outputs.

Only five of eleven graduate students are supported by TCCP funds. In terms of producing research relating to Project outputs, graduate students are considerably less expensive than technicians. Also, developing countries desire and need M.S. and Ph.D. students trained in developed countries.

C.,G. Assess cost-effectiveness of sub-agreements (sub-grants) for (i) equal partner cooperative; (ii) technical support networks; and (iii) pathbreaking research. Obtain and analyze data on sub-grants for (i) strengthening LDC labs (output 10) and (ii) involvement of U.S. universities (output 11) in research, field testing and information exchange.

Sub-agreements in developing countries are very cost-effective because of the low cost of labor in these countries. More of these agreements should be funded because, in addition to being cost-effective, they directly further Project goals related to technology transfer. Sub-agreements in the U.S. are useful to secure specific research or field testing expertise, but are less cost effective. First round field testing is more efficiently accomplished in the United States (except for rice) because field sites can be visited several times during the growing season.

D. Assess the cost effectiveness of Network support activities including publications, information, and personnel exchange.

Network support activities are very cost effective and link together large numbers of researchers in developing countries.

E. Assess the success of CSU/TCCP in obtaining the collaboration of IARC's within the network, particularly for (i) supply of germplasm; (ii) field testing; (iii) exchange of information on stresses affecting production expenditure and budget; and (iv) facilitating cooperative programs with network members (no project funds).

Germplasm and information are easily obtained from the IARC's. In the case of CIMMYT, CIAT, and ICRISAT specific collaborations on research and field

testing have been easily arranged. Field testing through IRRI has proven cumbersome so the Project is now cooperating with PCARRD.

F. Obtain and analyze data for cost-effectiveness of outputs and sub-outputs.

Cost-effectiveness of outputs and sub-outputs is difficult to assess until the Cooperative Agreement is complete. Representative figures for the cost of producing regenerated plants are provided.

H. Review pre-requests required for TCCP training courses, evaluation results, and follow-up.

The Project has received 87 applicants for its training course of which 57 were accepted and 24 attended. Lack of funding is the principal reason why accepted students could not attend. The Project's course is unique in that it's six month duration allows for thorough training including presentation of a research proposal and a seminar. A substantial length of time is spent on a crop of direct interest to the trainee so that the technology can be directly transferred to the country of origin.

ISSUE 4. MANAGEMENT DIFFICULTIES

AID is concerned that the TCCP is not yet being managed in a way that provides confidence that the grant purpose will be substantially and successfully achieved within the timeframe (five years) and resources being made available. The use of a cooperative agreement in lieu of a contract mechanism implies a close continuing and collaborative mode between CSU and AID which has not yet been fully achieved.

A. Only one Work Plan has been submitted to AID by August 1987, it did [not] delineate activities by grant year or provide cost estimates by outputs, and proposals for new research subjects were not included or identified as such.

By December 1987 the Project had submitted three Work Plans. Cost estimates by outputs were not requested by AID until 1987.

B. An annual progress report has been submitted for 8/31/84 to 10/31/85. A second report was submitted in July 1987 which was a cumulative of the TCCP activities during its first five years of existence and progress during the first two years (i.e. until 10/1/86) of the five year cooperative agreement. Besides their tardiness, these reports have not contained the information needed and in a manner to carry out the management functions and processes specified in the agreement and summarized above.

As of December 1987, two Annual Reports and a Progress Report (substituting for an Annual Report) had been submitted. The Project did not receive any specific guidelines about reporting until November, 1987.

C. The MRG has not been established and, with AID de facto, has been relegated to a passive role. TCCP recognition of this "collaborative or partnership" mode vis-a-vis contractor relationship is not demonstrated in the activities and documentation available to date.

The MRG met at the first Project Conference in October 1985. During the second Project year the size of the group was reduced and international members were eliminated due to travel costs. Currently, the group consists of Dr. Gill, Dr. Nabors, and Dr. Meiman. A Project Advisory Group has been established at CSU.

D. Their is concern by S&T/AGR that not enough time is devoted to managing the TCCP by the CSU Project Director, that there is inadequate delegation in some cases, too much staff turnover, and not enough attention devoted to planning and monitoring collaborative research and field testing.

The Project research is managed by a Research Management Group consisting of the Project Director, Associate Director, and Research Coordinator. All three of these people have Ph.D.'s. The Network and Training Programs are managed by an M.S. candidate and an M.S. respectively. The Project Operations

Director has an M.B.A. Field testing has the very highest priority among Project outputs. See Issue 2E. Collaborative research is monitored by yearly site visits.

ISSUE I. NEED FOR CLARIFICATION OF PURPOSE

A. There appears to be some confusion in design levels, e.g., the AID development/program goal or problem to which the Project is designed to impact and the specific purpose or objectives of the grant itself which can be measured by recognizable and finite end-of-project status indicators (EOPS). Does this require redefinition or clarification?

In answering this question we will cite the Cooperative Agreement of August, 1984 and particularly Section B in which specifics of the Project are detailed. Reference will also be made to the Work Plan of March 1985 and the Revised Work Plan of December 1987. Section B of the Cooperative Agreement also contains Work Plans for each year beginning on B5. These Work Plans were used as a basis for obtaining the March, 1985 document.

First, we will consider Agency and Project Goals.

The TCCP arose out of Contract No. DSAN-C-0273 and was continued by Cooperative Agreement No. DAN-4137-A-00-4053-00 between AID and CSU. AID entered into the Cooperative Agreement under the authority of the Foreign Assistance Act of 1961. According to this Act "It is the sense of the Congress that peace depends on wider recognition of the dignity and interdependence of men, and survival of free institutions in the United States can best be assured in a worldwide atmosphere of freedom.

"To this end, the United States has in the past provided assistance to help strengthen the forces of freedom by aiding peoples of less developed friendly countries of the world to develop their resources and improve their living standards, to realize their aspirations for justice, education, dignity,

and respect as individual human beings, and to establish responsible governments.

"The Congress declares it to be a primary necessity, opportunity, and responsibility of the United States, and consistent with its traditions and ideals, to renew the spirit which lay behind these past efforts, and to help make a historic demonstration that economic growth and political democracy can go hand-in-hand to the end that an enlarged community of free, stable, and self-reliant countries can reduce world tensions and insecurity.

"It is the policy of the United States to strengthen friendly foreign countries by encouraging the development of their free economic institutions and productive capabilities, and by minimizing or eliminating barriers to the flow of private investment capital."

On page B1 of the Cooperative Agreement, AID's assistance to Colorado State University is seen as a "furtherance of a mutual interest to accelerate and expand the use of tissue culture research and the products of such research for improved crop production in LDC's."

It is clear that this statement, on the first page of the Program Description, clarifies and specifies the Cooperators' mutual interest in attaining the goal of the 1961 Act.

Continuing on page B2 of the Cooperative Agreement, the Goal of the Agreement spells out this interest in somewhat more detail: "The goal of the program activities is to expand and accelerate the application of tissue culture research to LDC crop production problems by strengthening LDC capacity in this field and by linking and coordinating the worldwide research."

The Work Plan of March 1985 (and the Revised Work Plan of December 1987) specifies the Developmental Goal of the Project as "The Project seeks to accelerate the development of food crop varieties with higher yields under

conditions of environmental stress. It is intended that such cultivars can be grown on marginal land by small farmers in developing countries."

It is clear that the goals of the Foreign Assistance Act of 1961 are an umbrella which cover the more specific goal statements of the Cooperative Agreement and the Work Plan. In all cases, the unifying theme is to increase the ability of LDC's to produce food by improving available technology, training, and access to information (although these are really statements of objectives).

Second, we will consider the more specific Objectives of the Cooperative Agreement and the Work Plan.

The Project Objectives (as listed on page B1 of the Cooperative Agreement of August, 1984) further specify and enumerate how the Goal will be obtained:

1. Expand field testing of stress-tolerant plants, developed with tissue culture techniques, by establishing or expanding collaboration with International Agricultural Research Centers (IARC's) and selected LDC research institutions.

2. Provide required training to LDC researchers to improve their capability in plant biotechnology for crop production problems in their country or region.

3. Establish and expand a network of research institutions to share technologies, information, and materials.

4. Continue "pathbreaking" research to apply tissue culture techniques to research on additional crops which are important in LDC agriculture.

The Project Work Plan, of March 1985, specifies the Objectives of the Project somewhat more succinctly as:

1. To facilitate the establishment and strengthening of capabilities in selected developing countries to produce stress-tolerant crops.

2. To expand the knowledge base of biotechnology.

3. To increase the rate of plant biotechnology transfer and its use by developing countries.

In the first set of Objectives, field testing, training, networking, and research components are identified. In the second, the research component is clearly identified in 2. Training and Networking Objectives are given a capability (1) and a technology transfer (2) component. Field testing would be included both in 2 and 3. Project staff understood that anyone reading the Work Plan would also have access to the Cooperative Agreement. So the two sets of Objectives should be regarded as complementary.

Third, we will consider the End-Of-Project Status (EOPS) Indicators as first spelled out on pp. 4-5 of the March, 1985 Work Plan. These are:

1. Acceptance of use of tissue culture methods and germplasm by network collaborators as measured by field tests, published papers and reports, and trainees and graduates working in developing countries' tissue culture activities.

2. Acceptance and use of tissue culture methods by others (non-network) as measured by Science Citation Index references to published papers, invitations to national and international meetings, and requests for germplasm.

3. Increased financing of tissue culture activities by national and regional developing country sources.

4. Requests to CSU and to bi-lateral and multi-lateral agencies for technical assistance in establishing or strengthening tissue culture programs in developing countries as measured by USAID field missions PIO/T's, IARI's FAO, etc.

5. Requests by developing countries for assistance in applying tissue culture methods to new crops and/or new environmental stress factors or initiation of new programs with or without network assistances.

These Indicators seem to Project Staff to afford an adequate measurement of the Objectives as spelled out in the Cooperative Agreement and the Work Plan. It is suggested that during the last year of the Project, the EOPS Indicators be somewhat more sharply defined and specified so that the Final Report will be able to accurately report them.

B. It can be succinctly stated that the primary purpose of the Cooperative Agreement is to develop and demonstrate a proven technology to targeted end-users, i.e., LDC's and plant breeders. Is this purpose clearly understood and accepted by the principal participants?

This succinct statement of purpose seems tantamount at first to a restatement of goals. But really it is more than that, including a rationalization or reason for achieving the goal through the stated objectives. Tissue culture gained force as a method of increasing agricultural production during the 1970's when it became clear that useful variants could be selected in agriculturally-useful plants. The TCCP arose out of the knowledge and to validate the hypothesis that this developing technology (and other aspects of plant biotechnology) could be effectively used and effectively transferred to LDC's with their many agricultural problems and opportunities.

This statement of purpose clearly demonstrates that the Project has a developmental component as well as a utilization component. Each of the Project Objectives, whether relating to research, field testing, training, or networking is concerned with or is a series of outputs tied directly to the process of crop improvement in the LDC's.

For example, the curriculum of the Training Course must include simple, proven experimental techniques designed to work with specific crop plants. The trainees who come to learn the curriculum must be people from LDC's who have the need to use these techniques in their particular home positions. Finally,

the graduates of the Training Program must return to their home with knowledge and future access to knowledge sufficient to insure that their training will make a tangible difference in the agricultural objectives and bureaucracy of their homeland. So, in the Training Program, the pathbreaking research is important as a means of supplying usable techniques, field testing is important to verify that useful plants can be produced by these techniques, and the International Plant Biotechnology Network (IPBNet) is vital as a communications link to optimize utilization of the training received. All of these Project components support the training itself and markedly influence its effectiveness.

C. What is the overall research hypothesis which needs verification and how will this be accomplished within the resources and time frame provide in the existing agreement? Is this adequately reflected in the EOPS indicators?

The Development Hypothesis or Justification for the Project and the Project Approach or Hypothesis are discussed on pp. 1-2 of the March 1985 Work Plan as follows:

Development Hypothesis or Justification

1. There are limits on what can be done to modify the environment to increase and sustain crop yields. For example, irrigation requires fresh water and 80% of readily available water is already used for agriculture. Irrigation systems, regardless of careful management, cannot eliminate salt build-up. Soil liming to reduce acidity is neither practical logistically nor financially possible in many areas. The high costs of mechanized agriculture, fertilizers, etc., severely constrain environmental modifications in the least developed countries and, as energy cost rises, increasingly in the more developed countries.

2. It makes sense under these conditions to approach these problems (see Background) by working to modify the plant to suit available environments.

If, for example, the drought tolerance can be increased, then (a) land currently too dry for agriculture can be brought into cultivation; (b) the extent of coverage by available irrigation water can be extended; (c) salt build-up due to irrigation will be slowed because irrigation is reduced with respect to amount and frequency and (d) resources currently devoted to environmental modification and, in some cases, food importation, can be redirected.

3. Tissue culture research offers plant breeders a mechanism for speeding up the development of crop cultivars that are resistant to stresses such as those mentioned. This technology produces rapid selection mechanisms using only a limited amount of space and number of people.

4. However, use of emerging biotechnology focused on tissue culture methodologies is currently impeded by a number of problems, some typical to agriculture in tropical and sub-tropical areas, and others unique to plant biotechnology. These include:

a. Lack of fully developed and tested technologies and methodologies, especially for regenerating stress-tolerant crops important in DC's;

b. Failure by plant breeders, agricultural leaders and financing institutions to recognize potential cost-effective value of successful Plant Tissue Culture (PTC) technology applications in solving the problems of DC crop production;

c. Insufficient exchange of information;

d. Lack of problem-solving capabilities in many DC's including lack of trained people and facilities and insufficient funds.

Project Approach or Hypothesis

The Project Objectives are interrelated and represent an approach which is a combination of research and development, training, technology

transfer, and application. The focus is upon those problems which impede the development and transfer of biotechnological knowledge and capabilities and their use by developing countries in solving agricultural production problems. It employs the networking concept as a device to expand the knowledge base, increase DC capacity and facilitate transfer and utilization. The Project also provides the means to expand the involvement and increase the capabilities of CSU in several areas of plant biotechnology and assist interested DC's develop their own capabilities and programs. The results (outputs) of Project activities, along with other events beyond the scope of the Project, for example increased national and multi-lateral support, are expected to result in independently verifiable achievement of the Project Objectives by 1990.

In a sense, increasing agricultural projection in LDC's is a black hole which can readily absorb any and all resources developed to it. Even a single aspect of agricultural improvement can use immense amounts of resources. The research hypothesis for the TCCP is based on the idea that ultimately modifying the plant to suit available, albeit stressful, environments is more effective in the utilization of available resources than using liming, irrigation and other methods to modify the environment to suit the plant.

The research hypothesis includes the assumption that plant tissue culture can economically, rapidly, and effectively help the breeder obtain stress tolerant crop plants. This is because the selection process uses cells instead of field-grown plants and because tissue culture methods can rapidly propagate useful variants as well as substantially increase the mutation rate to produce new variants.

Finally, the research hypothesis assumes that LDC's lack the resources and trained manpower to effectively develop plant tissue culture techniques and to use them to increase the stress tolerance of commonly used cultivars. An well-

developed program of technology transfer which includes research, training, and networking components can be useful in helping the LDC's to increase agricultural production by using new plant biotechnological techniques.

In terms of the EOPS Indicators, Project staff feel that they adequately reflect the verification of the research hypothesis. During the final year of the Project, the EOPS indicators need to be detailed so that the final report adequately shows all aspects of research hypothesis verification.

D. In the remaining term of the Project, how much level of effort should be on plant protoplast and molecular biology to isolate and transfer the genes for stress tolerance traits? How would this change the EOPS indicators and/or time frame, if at all?

Page two and pp. 35-41 of the Revised Work Plan of December 1987 explain that a Special Focus on genes responsible for stress tolerance was added to the Project in 1986. The development of techniques for regenerating crop plants from protoplasts are part of the original Work Plan of March 1985 (output 1e). At present, funding for the Special Focus ends in September 1988, a year before the Project ends. It is our opinion that additional money will be needed to continue the Special Focus through the end of the Cooperative Agreement. The time frame is outlined in the Revised Work Plan (Outputs SF-1, 2, 3).

The TCCP has always focused on those techniques of plant tissue culture and plant biotechnology which are on the interface between basic and applied research. The lab was the first in the world to demonstrate, for example, that salt tolerance which was selected in tissue culture could appear in a stable form in regenerated plants.

The Project investigates techniques in a number of phases of development. In some cases, field testing is the critical component which needs proof. In other cases greenhouse testing, or laboratory research may be the critical

component needing validation. It is important for the Project to be working simultaneously on techniques with nearly proven practical utility as well as those which require a few years of further laboratory development. In this way the pipeline of technology transfer will be unbroken and LDC scientists will be placed on an equal technological footing with their counterparts in developing nations.

Developing Country scientists need to learn technique development as well as technique utilization. The EOPS indicators need to be detailed to include indications of progress in there areas. The present scope of the indicators is adequate. It is therefore extremely important for LDC scientists and plant breeders to be fully informed, trained and aware of developing techniques such as regeneration from protoplasts and identifying and transferring genes responsible for stress tolerance. A good deal of the important developmental work of these techniques is done in the TCCP labs by LDC scientists and trainees. They focus not only on making the techniques work but also on making them reproducible and simple enough so that they can be of utility in a home environment with a utilitarian and focus and (by some standards) inadequate resources.

It is important to point out that even since these Issues were raised in September 1987, important progress has occurred in each of these frontier areas.

ISSUE 2: SLOW RATE OF RESEARCH PROGRESS AND POSSIBLE NEGATIVE EFFECTS ON SUCCESSFUL PROJECT COMPLETION BY 1989.

AID is concerned that insufficient progress has been made in the development of appropriate methodology and in the field testing and demonstration of results.

The defined objectives and the work to meet the specified objectives and expected results for each grant year are listed in the Cooperative Agreement,

Attachment B. The Work Plan of March 1985 was developed from Attachment B and is more specific as to actual tasks.

The progress in technology development and their applications according to the Work Plan of 1985 have been presented in two Annual Reports (Grant Years 1 and 3), a Progress Report (Annual Report for Grant Year 2), five Newsletters, Quarterly Reports for Grant Year 3 and the first Quarter of Grant Year 4, and refereed publications.

An attempt is made in this document to compile the information on technology development (pathbreaking research) and the status of their applications aligned with the respective proposed outputs and sub-outputs.

The documentation records progress and new advances and achievements which have been accomplished within the Tissue Culture for Crops Project and through national and LDC collaborators. The table in this section highlights achievements in plant regeneration techniques (Output 1a) and summarizes *in vitro* selection (Output 1b). In several areas—legumes in particular—unexpected accomplishments were achieved and the TCCP became a leader. In other areas, such as the stress tolerance screening, the program was less rapid than predicted in the 1985 Work Plan; more time was required for the screening and subsequent plant regeneration than was anticipated when the 1985 Work Plan was written.

A fact which also had a significant influence on progress relates to facility availability. The initial Work Plan and the documents including Attachment B were prepared and were to have been implemented in August, 1984. The facilities needed to perform the proposed research became available for use in August, 1985. Furthermore, the move to new facilities caused a disruption in the experiments in progress.

The issue of designating a high proportion of end results for the fifth year reflects the fact that we believe five years are required for successful development of the new, efficient technologies to be implemented to achieve the end result. Tissue culture requires one to three years for developing regeneration procedures or for regeneration of plants for field testing after the regeneration procedures are known. Field evaluation requires two to four years for confirmation of stability and heritability of useful traits. This necessitates many end-results in the final grant year. If this Project is not renewed much field evaluation will not be completed by the end of the current Cooperative Agreement. These time requirements have been brought into sharper focus in the past year based on information collected from in vitro and field evaluation.

Difficulties relating to production of reports are discussed in Issue 4. In brief, guidelines for report preparation were not made clear to TCCP by AID personnel until November, 1987. At which time revision and preparation of several documents were undertaken and completed.

A. Given the baseline established in technology development at CSU before execution of the cooperative agreement (through AID and other support), for what sub-outputs has progress been less or more than should be expected? How does this progress or lack thereof affect (i) development of methodology; (ii) developing specific stress tolerance for selected crops; and (iii) demonstrating and gaining acceptance of results by targeted end-users?

The Outputs 1 of the 1985 Work Plan will be addressed in the present report. This output deals solely with the tissue culture component. Output 2 is discussed in Issue 2e.

A completely revised Work Plan was issued to and approved by USAID in December 1987. In the 1985 Work Plan each sub-output contains a section on

"Results to 1984." For the 1987 Revised Work Plan, the sections written for each sub-output in 1985 were retained and additional sections on "Results from 1984 to 1987" and "Problems Incurred" were added. These sections provide greater detail than the original Work Plan. The background information and significant aspects of the changes made in the revised Work Plan are presented below, and should be of value as background information.

Organization of the Work Plan

The individual outputs and sub-outputs are divided first by Grant Year 4 or Grant Year 5. Each Grant Year is sub-divided by major activities and tasks. The tasks have been given specific target dates for completion; if a task will not be completed in Grant Year 4 the target date is marked with an asterisk and in Grant Year 5 the task is repeated with a specific completion date.

Highlights of Changes Made in Revised Work Plan

The Work Plan as originally designed consisted of defined Outputs with several Sub-outputs. That design has been generally preserved. However, the major activities, tasks and milestone events have been adjusted to be in line with the status of technical development, realized or potential. Consideration also had to be given to available skills in line with reduced budgetary resources. The adjustments have been made in consultation with USAID management. The changes that have been incorporated are outlined below in Research and Development and the IPBNet, respectively.

In the cereal programs, the research at TCCP focuses on rice, wheat (spring), sorghum and millet. Corn was previously also included, but that program was transferred to one of the DC collaborators, Dr. Nguyen Thanh-Tuyen, ViSCA, Philippines, and is supported through a subgrant from the TCCP.

The number of stresses selected in each crop was also reduced. The changes were made on the basis of the experience gained from the research during the first one to three years. For example, it is now clear that the stress selection requires six to eighteen months to complete. The TOCP inventory of salt-selected R_1 plants of rice has reached 2500 lines. The emphasis will now change to aluminum tolerance screening. Similarly in wheat, the inventory has reached 3000 R_1 lines screened for salt tolerance which have gone on to seed increase and field testing. The stress screening in wheat will be aluminum and PEG (drought) in that order and as personnel are available. In sorghum, the stress selection will be aluminum tolerance and in millet, drought tolerance.

The legume program has received increased emphasis the past year. The research on soybean was well advanced, but was discontinued in 1986 at the request of USAID management. Since no reliable procedures for plant regeneration in grain legumes were available, emphasis was placed on developing such procedures. The species in the program were Phaseolus spp. (common bean, tepary bean), Vigna spp. (V. aconitifolia, cowpea), and Cajanus cajan (pigeonpea). These grain legumes were tested in parallel experimentation, because in spite of numerous reported attempts, no plant regeneration procedure needed for long-term screening had been developed. Moreover, since the plant regeneration capability is a genetic trait, the chances for success in one species might be considerably better than would be the case for others. Success was achieved in developing plant regeneration methods for long-term culture for Phaseolus (tepary bean), pigeonpea, and Vigna aconitifolia (also known in India as moth bean). Salt-tolerant lines of these species are being used to provide regenerated plants for field testing. Tepary bean is scheduled for aluminum tolerance screening.

Research on plant regeneration methods for common bean and cowpea had progressed successfully to the stage of somatic embryogenesis, but had to be stopped due to budgetary restraints.

The other major changes in the revision are in regard to Output 1c and what was Output 1f. The research in 1c (previously 1d) was changed to include a program to determine if proline overproduction could be developed as a practical indicator and diagnostic tool to test for stress tolerance. The research in 1f (now part of SF-3), was originally focused on cloning the gene(s) for nitrate reductase and transferring the cloned genes to rice. The objective and research were changed in 1986 to focus on applying molecular biology procedures to cloning genes for stress-induced proteins and salt tolerance. The research became a collaboration with Dr. J. Colbert, Department of Biology, Colorado State University. The TCCP did not have the space or the equipment required for the program. The objectives of the Special Focus were to apply and take advantage of the developed biotechnologies in molecular biology and genetic procedures. The Special Focus covers areas in which genetic procedures of widecrosses by sexual means (formerly Output 1c, now Output SF-1) and cell fusion as well as genetic transformation are combined with tissue culture procedures to produce stress-tolerant germplasm which cannot be obtained by standard procedures (SF-2 and SF-3).

In the Outputs on the International Plant Biotechnology Network (Outputs 3-11), many of the activities have been completed. Outputs 5-11 were condensed into Outputs 3a - 3c to eliminate redundancy. No major activities have been eliminated, however. Major activities specify in each Output which tasks will continue into grant years four and five.

SUMMARY OF OUTPUT 1

Output 1a. Techniques for obtaining plant regeneration.

Plant regeneration for rice, wheat and millet been been accomplished prior to this Project. Regeneration in sorghum was accomplished in 1985 and was reported in 1986 in Newsletter No. 6 and in MacKinnon et. al. (Plant Cell Reports, 1986). This was two years ahead of the 1985 Work Plan target date.

Corn has been much more difficult. Regeneration was achieved in 1986 but only at low levels by TCCP and at more efficient levels from the subgrant to Dr. Tuyen at VISCA. Even at these levels, regeneration was achieved one year earlier than the estimated end date in the 1985 Work Plan.

Regeneration from soybean cultures were reported in 1987 (Ghazi, Plant Cell Reports), from suspension cultures of mothbean and pigeonpea in 1988 (in press). Development of somatic embryos have been observed from suspension cultures of cowpea and bean. These reports for the legume are also ahead of the 1985 Work Plan target dates.

Plant regeneration from rice suspension cultures have been achieved and reported in Newsletter No. 8 (1988) well ahead of the estimated end date of 1989. Wheat suspension is being pursued but as of February 1988 regeneration has not been achieved.

Refinements of many of these regeneration techniques are being made. Further improvement of the basic tissue culture will enable TCCP to improve its ability to assist developing countries in utilizing the technology.

Output 1b. Techniques for selecting tissue cultures tolerant to environmental stresses and plant regeneration from stress-tolerant cell lines.

Experiments at the TCCP in which cells are cultured on media containing stress agents are on schedule (based on the 1985 Work Plan) or ahead of schedule in most cases (Table 1). Work is reduced on NaCl at this time with between 1,000 - 2,500 plants regenerated from rice, wheat, and sorghum salt-

selected tissue cultures. Experiments on Al and PEG are increasing with determination of selection levels and generation of germplasm.

Output 1c. Techniques for using tissue culture to promote gene exchange in wides crosses.

This output in entitled SF-1 in the 1987 Revised Work Plan. The tasks associated have also been modified. Much of the work completed has dealt with culturability of species which have karnal bunt tolerance (Work Plan 1987). "Several cultivars of Triticum aestivum and T. turgidum were evaluated and five T. aestivum and six T. turgidum were selected on the basis of their crossability potential for further study associated with hybridization with alien species. Callus cultures of these cultivars were established by June 1986. Several Aegilops accessions were identified which had resistance to karnal bunt. This is the alien genus selected for transferring karnal bunt resistance to wheat via tissue culture. Several F_1 hybrids of T. aestivum/Ae. variabilis have been produced, embryos excised and put into tissue culture."

Table 1. Summary of activities *in vitro*.

Crop	*In vitro* condition*	Target Dates** from Work Plans 1985	1987	First Plants Harvested	Cultures in Progress	Number of Plants Grown to Seed
Rice	reg.	—	—	—	-	—
	NaCl	84-87	—	9/83	+	2062
	Al	84-87	88	7/84	+	541
	PEG	84-87	89	5/85	-	8
Wheat	reg.	—	—	—	-	—
	NaCl	84-87	—	11/85	+	3177
	Al	84-87	89	—	+	—
	PEG	84-87	89	—	+	—
Millet	reg.	—	88	—	+***	—
	NaCl	84-87	88	10/84	+	499
	Al	84-87	89	5/87	-	270
	PEG	84-87	89	—	+	—
Sorghum	reg.	84-87	88	4/85	+***	—
	NaCl	85-88	—	6/85	-	1577
	Al	85-88	88	5/87	+	171
	PEG	85-88	89	—	-	—
Corn	reg.	84-87	89	11/86	+	—
Soybean	reg.	84-89	—	7/86	-	—
	NaCl	84-89	—	2/87	-	35
Tepary bean	reg.	—	—	9/87	-	—
	NaCl	—	—	12/87	+	11
	Al	—	88	2/88****	+	—
Vigna	reg.	—	—	12/87	-	—
	NaCl	—	88	12/87	+	46
	PEG	—	—	2/88***	+	—
Pigeonpea	reg.	—	—	10/87	-	—
	NaCl	—	88	10/87	+	59
	PEG	—	—	2/88***	+	—

* Development of long-term, high-frequency plant regeneration (Output 1a) or *in vitro* selection (Output 1b).

** Dates are for the task of plant regeneration.

*** Low rates of E callus formation are being improved.

**** Plants are either in a growth chamber or greenhouse.

Output 1d. Techniques for selecting tissue cultures more efficient at reducing nitrate and regeneration of plants from cell lines with altered nitrate reductase activity.

This sub-output is 1c in the 1987 Work Plan. "Chlorate resistance studies revealed that callus from IR-36 can withstand 50 mg/l $KClO_3$ for five passages. Plants were regenerated from selected callus and are being grown to maturity."

Output 1e. Techniques for obtaining plant regeneration from cereal protoplasts.

This topic is discussed in the answer to Issue 2c. Output 1e of the 1985 Work Plan is 1d in the 1987 Work Plan.

Output 1f. Techniques for cloning nitrate reductase and introducing cloned nitrate reductase into protoplast.

This project has been changed to study salt-tolerance genes and is output SF-3 in the 1987 Work Plan. Discussion of this project is under the answer to Issue 2c.

SPECIFIC POINTS OF CONCERN IN 2a.

Development of methodology. Tissue culture technology, the ability to maintain callus and regenerate plants, is adequate to perform in vitro selection as discussed above. Difficulties have occurred due to new personnel not overlapping with the previous personnel and therefore losing information and in slow or low rates of E callus formation requiring large numbers of cultures to be started. This is a time problem and various management and research projects are ongoing to improve this situation. Regeneration from suspensions and protoplasts are very speculative projects, but progress is being made to the point of plant regeneration from rice suspension cultures and most of the pulse crops.

Development of specific stress tolerance for selected crops. In vitro methodology is not a hindrance to developing large number of regenerates from

wheat, rice, or legume *in vitro* selection. But sorghum and millet are slower in E callus formation and therefore require more cultures to obtain necessary amount of E callus for stress experiments.

Acceptance of results by targeted end user. Tissue culture, in-and-of itself, is readily accepted by most plant physiologists. Acceptance by plant breeders, in general, will require releasing germplasm useful to their situations.

B. How much research has been assigned to collaborating institutions and how well is it planned, facilitated, and monitored by TCCP?

Collaborative research can be categorized into three areas: 1) Field evaluation, 2) subgrants, and 3) visiting scientists. Collaborators are listed in a table in Issue 3d and summarized where they fit into the Work Plan.

Field evaluation could not be accomplished without collaboration from plant breeders. Our role is to design the field plots and to develop field plot books. The collaborator puts together the field planting plans, plants the seed, and observes the plots. Personnel from TCCP visit the site once a year if it is international and twice if it is domestic. Most collaborators harvest and clean the seed before returning it to the TCCP. Reports are received from the collaborator after planting and harvest.

Proposals for subgrants are reviewed by TCCP and modifications are advised. Quarterly and Annual Reports are required from scientists receiving subgrants. Periodic visits by the Project Director have been made to these labs to discuss the research.

Visiting scientists have become a valuable resource. These scientists come to TCCP for a period of 6 to 12 months. They are given projects which directly relate to the Work Plan in most cases. They are also required, by their home institutions, to write quarterly and annual reports. The visiting

scientists are assigned to one of the Research Coordinators for consultations concerning the research.

C. Given the current inadequant, state-of-the-art in plant regeneration from protoplast and cell suspension culture of cereals and legumes and the technologies for the "identification of genes controlling resistance to stress and our ability to isolate and move them", is it realistic to presume that output can be accomplished by 1989?

The concerns expressed in Section C touch on at least four topics:

Topic 1. Plant regeneration from cell suspension cultures (Output 1a)

Topic 2. Protoplast technology including plant regeneration (Output 1e)

Topic 3. Identification/isolation of genes for stress tolerance (gene cloning, Output 1f)

Topic 4. Transfer of genes (Output 1f)

All of the topics are included in the category of pathbreaking research (Attachment B). The research is to be undertaken as basic research for technology development with potential application for crop production problems in the LDC countries. The technologies are to be transferred through training and collaboration (Attachment B). The research in Output 1f is to proceed in line with progress in the development of technologies in plant molecular biology. (Work Plan 85, p. 7, C-6)

Each of these topics are discussed below in relation to target and possible completion dates.

Topic 1. Plant regeneration from cell suspension cultures. See Output 1a in Work Plan 1985

Culturing cells as suspensions and regenerating plants from such cultures was included as a Major Activity. It is an alternative culture system to callus and was to be done on a limited scale in crops such as wheat and rice. It is well known that cell suspension cultures may be more effective for

screening; however, it is equally well recognized that the plant regeneration process is much more difficult to achieve in suspension cultures than from callus. The research with suspension cultures of wheat and rice has been pursued in graduate student projects. The conditions necessary for plant regeneration (a milestone) has been defined for rice.

An accomplishment of major significance is the development of plant regeneration systems from long-term suspension cultures of grain legumes. Substantial efforts were made, initially, to develop the callus culture system as used for cereals, but culturing and regeneration beyond three to four months became impossible. Parallel experiments performed with liquid suspension cultures were successful, and long-term culturing and plant regeneration has become a proven technology in two grain legumes (see Issue 2-a).

One of the reasons for the success was a modification of the traditional procedures. Separation of the cell cultures according to size of cell aggregates and using the correct fraction was a crucial feature. This success has made the TCCP the leader in the grain legume plant regeneration technology worldwide.

The target dates for completing research on long-term culture and high-frequency plant regeneration in legumes was September 1989 but was completed for three grain legumes in September 1987 and thus is well ahead of schedule. The research on rice suspension cultures which has resulted in plant regeneration from suspension cultures was also completed in September 1987 and thus is ahead of schedule (September 1989).

Topic 2. Protoplast technology including plant regeneration. See Output 1e Work Plan 1985 (Output 1d, Work Plan 1987)

The major activities were set-up with the objective of developing the technologies necessary for isolation, culture and plant regeneration from

protoplasts of cereals—particularly rice. That program or Output is of the pathbreaking category and has always been recognized as high risk research. The research with protoplasts was undertaken by graduate students and continues to be carried-out by graduate students and visiting scientists, but the work is directed towards specific applications in the production of cell fusion hybrids (see Annual Report 1987, pp. 111-120).

Research is in progress to define and optimize the conditions for isolation of viable protoplasts in rice and millet. That is part of the suboutputs and is on schedule. The tasks of achieving plant regeneration from protoplasts scheduled for a target date of September 1989 is possibly realistic. More information about the necessary techniques is now available and the chances are fair that the tasks can be accomplished for one crop by the target dates.

Topic 3. Identification of genes which control stress tolerance

The topic of molecular biology is addressed together with Issue No. 2d. The Work Plan 85, Output 1e outlines activities and tasks directed at nitrate reductase and the transfer of cloned gene(s). The long-term general intent was related to nitrogen utilization efficiency (Attachment B). The objectives of Output 1f were changed in 1986. In 1986, the TCCP was asked by AID to propose plans for expanded activities in biotechnology. In the proposed research, a program was included for the application of molecular biology for the purpose of identifying genes for stress tolerance. Upon approval of the proposal, the molecular biology program was shifted from nitrate reductase to salt tolerance genes.

At the inception of the Cooperative Agreement there were neither personnel nor facilities to undertake the output tasks. That situation was rectified and research was started in 1986, when the Special Focus plan took effect. The research now is directed at identifying gene products, proteins of salt stress.

The rationale is that such proteins are indicators of salt tolerance. Attempts will then be made to demonstrate their role in salt tolerance. Using relevant suboutputs of the Work Plan 1985, the research is on target in spite of the delays in starting. As an example, the target date for the cDNA library is September 1988 which is the date in the 1985 Work Plan. The completion of the entire output as now defined in the 1987 Work Plan, SF-3, is not expected by September 1989. The reason is primarily a time factor rather than limitations in technology.

Some of the suboutputs will involve one or more collaborators from other universities in the USA. Dr. G. An at Washington University has agreed to participate in the work on preparing the expression vector for plants for the TCCP cloned stress tolerance genes.

Topic 4. Gene transfer and expression.

Research is in progress to define the conditions for transferring and expressing foreign genes in plants. That is part of the suboutput in molecular biology as specified in the 1985 Work Plan. The limitations in the task of achieving genetic transformation is usually the plant regeneration step. The strong capability at TCCP for regenerating plants efficiently from cultured cells makes it feasible to undertake the task of genetic transformation. The novel system consists of transferring a gene which confers tolerance to the herbicide "Round-up" to tepary bean. The gene is provided by the Calgene Co. The transformation protocol will then be used to evaluate genes for stress tolerance. The completion of the task to demmonstrate the transfer and expression of foreign genes is a realistic goal for September 1989.

The research is within our capabilities and maximizes the expertise at TCCP of the plant regeneration capabilities.

D. On what basis were the "Project objectives" expanded in 1986 to include molecular biology? What are the budgetary and scheduling ramifications of such an expansion of project outputs? Where is the expected output described?

In 1986, the TCCP was invited by USAID to suggest areas of expansion in biotechnology—especially molecular biology—which could be aligned with Outputs of the Cooperative Agreement. A proposal was subsequently prepared and submitted. The Output paper became identified as the "Special Focus" and included as the June 1986 Modification to the Cooperative Agreement.

Under the Special Focus plan, three processes or approaches are being studied to produce new salt- and acid-tolerant hybrids which cannot be obtained by standard crop breeding techniques alone:

1. Produce Widecrosses requiring embryo culture. To produce widecrosses between domesticated and wild species by hand pollination and by tissue culturing of the widecross embryos. The technology would also increase the frequency of chromosome translocation in hybrid plants which would then be repeatedly back-crossed to domesticated parents.
2. Produce Hybrids by protoplast fusion.
   To produce hybrids between highly-stress-tolerant plants and cultivated lines by fusion of protoplasts of the two parents. The resultant hybrid cells would be cultured to regenerate plants, which in turn would be backcrossed to the crop plants to transfer the trait.
3. Identify genes for stress tolerance.
   To identify and characterize the molecular genetic material for stress tolerance. The methods would include gene cloning and transformation to transfer the genes for stress tolerance to crop plants.

The goals of the research would include the stated objectives of practical results but would also provide a new understanding of the genetic basis for the stress tolerance traits.

The research categories of the Special Focus all relate to some of the Outputs in the 1985 Work Plan. The sexual crosses with alien species in Output SF-1 is essentially the same as Output 1c, but a sub-output now includes a legume. (Work Plan 1987, SF-1). For an update report see Annual Report 1987. The Output is now identified as SF-1 in the 1987 Work Plan.

The cell fusion hybridization Output is a collaboration with The Nuclear Institute of Agriculture and Biology (NIAB). The research has been carried out at TCCP by a visiting scientist from NIAB. The purpose is to produce hybrids between basmati rice and kallar grass—a highly-salt-tolerant grass. The hybrids are then backcrossed to rice to transfer the trait. The research is an approach to transfer salt tolerance from kallar grass to rice. For information on the project see Newsletter No. 8, page 7 and Annual Report 1987 pages 111-118. The research has been supported by USAID/Pakistan and NIAB. The project is now identified as SF-2. Two publications are in preparation.

With respect to Molecular Biology, the 1985 Work Plan had an Output (1f) for cloning of the nitrate reductase protein. At the inception of the Cooperative Agreement, there were neither personnel nor facilities to undertake the suboutputs.

The Special Focus project paper proposed molecular biology directed at identifying genes for stress tolerance. The major activity and tasks were subsequently defined for research on salt tolerance genes and Dr. J. Colbert of the CSU Biology Department was contacted and a decision was made to establish a collaborative program. The molecular biology research is performed at the laboratory of Dr. Colbert, while the genetic transformation is being carried out at the TCCP. The major activities are defined in Output SF-3 of the 1987

Work Plan. The progress to October 1987, is reported in Annual Report 1987, pages 121-124.

Budgetary and Scheduling Ramifications. The funding for the Special Focus expansion of the original Cooperative Agreement grant was fixed at $200,000. The funds were to cover the period from October 1, 1986 to October 1, 1988. The tasks, activities, and outputs are formulated in the Modification of Cooperative Agreement, Attachment A, and defined in the 1987 Work Plan. Because of the close parallel of the Special Focus Outputs with some of those in the original Cooperative Agreement, major activities have been integrated. Consequently, Output 1c of the 1985 Work Plan is part of SF-1 in the 1987 Work Plan. Similarly, 1f has become SF-3. These "mergers" have been taken into consideration in the budget. Although the $200,000 is a separate financial input, the financial statements relate directly to Outputs. The major item is Molecular biology/Widecross (see financial statement).

Since the Special Focus funding was designated to cover the period ending October 1, 1988, provision for further support becomes imperative to ensure that tasks and activities can continue. An additional $125,000 would be required to continue the Special Focus to September 1, 1989.

E. How adequate and/or standard is or should be the research methodology being used and/or planned for the fieldtesting of stress-tolerant cultures and validation of TCCP developed tissue culture methodologies? Reporting to date does not seem to indicate that the Project network (IPBNET) is as yet effectively involved in the field testing, validation and demonstration aspects.

Debate has arisen concerning which generation is appropriate for stress evaluation in the field. The question, for now, has been answered as follows. The trait would be expressed as early as the R_1 generation but the number of

seeds available in the R_1 is usually insufficient for adequate screening. Therefore, R_1 seed is advanced to the R_2 generation to provide enough seed to evaluate that line in several environments. Evidence from sorghum field evaluations of R_2 material indicates that lines derived from non-stressed cultures or from salt-stressed cultures may have tolerance to acidic soils, fall armyworm, and sorghum midge (Newsletter Nos. 7,8). Therefore, it may be advantageous to look at each line produced from tissue culture in several environments to identify non-selected as well as selected variants. After the R_2 evaluation, those lines having tolerance to the environment must be confirmed in at least the R_3 and probably the R_4 before germplasm can be released. After two to three seasons, the trait would be known to be stable and heritable and therefore useful to breeders.

Originally, the collaborators were composed primarily of scientists whose interest was in tissue culture and plant physiology. As the TCCP progressed into more greenhouse and field testing over the past two years, plant breeders with an interest in collaboration and testing of <u>in vitro</u> derived material have been added to the Network and are involved in many of the current Memoranda of Agreement (see Table under Issue 3D).

Early generation evaluation (R_1 to R_4) requires close collaboration with the breeder. TCCP personnel must visit the site to obtain information such as vigor ratings or seed set. The collaborators will harvest seed and send data they have collected with the seed back to TCCP. The TCCP for scientific and political reasons must set-up each field and make one to two site visits per season. In 1987, TCCP handled 11 sites worldwide. This is about the maximum number of sites which can be handled with the personnel and resources available at the TCCP. After the R_4 generation, when tolerant germplasm has been identified and confirmed, the tolerant germplasm will be released to breeders worldwide expanding TCCP's impact on breeding programs. Information from field

evaluations at this stage will be limited as breeders incorporate TCCP's material into their programs.

ISSUE 3. LACK OF SUFFICIENT INFORMATION ON THE COST OF PRODUCING OUTPUTS AND SUBOUTPUTS.

Despite AID requirements, CSU has not provided information which will permit a cost-effectiveness analysis to determine Project options or priorities given resource and scheduling constraints.

The Cooperative Agreement has no directives which require the preparation of cost-effectiveness analyses. A thorough analysis would best be carried out by a statistician. The following information represents the TCCP Management's best efforts toward providing the information requested.

A. Compare the results of annual IPBNet conferences with expectations, costs, and alternatives.

It is difficult to judge cost effectiveness of conferences of this nature, except to compare them with similar conferences which is beyond the scope of this report. It is clear, however, from feedback we have received, that a gathering such as this gives everyone—particularly LDC participants—the opportunity to 1) make personal contacts, 2) seek information from a variety of sources not usually available to them, 3) present and share new advances in technology, and 4) share needs and opportunities for establishing collaboration in research and applications of plant biotechnology. It would be prohibitively expensive for a researcher to visit even one tenth of the number of persons individually as are collectively available at such an international conference. The reasoning behind the IPBNet conferences, in particular, is to encourage further research and collaboration among scientists. Such inter-change is not possible through reading scientific publications or visiting one or two labs.

Following is a breakdown of expenses for IPBNet Conferences I and II:

TCCP Budget for Conference I	$50000	
Revenues (fees)	2104	
Expenditures	41964	
Cost per participant	446	
Number of participants		94
Number of participants supported by TCCP		19
Number of TCCP staff attending		28
Number of Countries represented		21
TCCP Budget for Conference II	$48000	
Revenues (fees)	3136	
Expenditures	33071	
Cost per participant	419	
Number of participants		79
Number of participants supported by TCCP		6
Number of TCCP staff attending		5
Number of Countries represented		18
Total Conference Budget for Grant Years 1 - 3	$14300[illegible]	
Total Expended	$ 750[illegible]	
Total Savings	$ 67965	

The cost per person does not include funds to participants supported by sources other than TCCP. In terms of TCCP's cost, both conferences were well under the original budgets. Eventually, the cost is anticipated to decrease to less than half the original budget as TCCP gains support outside of its own, limited financial resources.

179

B. Compare the cost of TCCP support of graduate students with their contribution to producing outputs.

First of all, it should be recognized that training and education of graduate students helps to fulfill the Project's mandate of transferring tissue culture technology to developing countries. Of the eleven graduate students currently at the TCCP, eight are from developing countries, eight are working on research problems directly related to Project outputs, and only five are fully supported by the TCCP. The average cost per student per year for these five is $11,569 (total cost per year, $57,845) for tuition and stipend. Spread over the eight students, this reduces to $7,231 ($57,845 - 8) per person for an average of 20 hours per week of research. Further realizing that the majority of these graduate students are working toward Ph.D. degrees, and comparing them to full-time, masters-level researchers whose average salary and benefits cost the Project $19,073 per person per year, it is easy to see that the $4,611 per person (based on full-time) savings more than balances any minor decrease in efficiency.

In addition to looking purely at cost efficiency, we must consider the ultimate effect graduate education at CSU with the TCCP will have on tissue culture labs in the developing countries to which most of these students will return. The majority of these students come from labs visited by the Project Director prior to or during the first year of the Cooperative Agreement. A need to increase the numbers of Ph.D.'s trained in plant biotechnology was perceived by both parties and the students are one means of answering this need. The graduate students are expected to return to their respective countries where they will become leaders in the introduction and implementation of plant biotechnologies.

GRADUATE STUDENT ACTIVITY

Name	Country	Project	Associated Output
Hidayat	Indonesia	Protoplast fusion/ potato	1d
John	Pakistan	Salt tolerance mechanisms	SF-3
Ketchum	USA	Protoplast regen/ rice, millet	1d
McMurray	USA	Characterization of somoclonal variation/ rice	n/a
Mohmand	Pakistan	Drought tolerance/ wheat	1b
Novero	Philippines	Nitrate reductase/ rice	1c
Poonsapaya	Thailand	Suspension regen/ rice	1a
Puthigae	India	Conditioning factor/ rice	1a
Sasi	Libya	Regeneration/triticale	n/a
Widiyanto	Indonesia	Blast resistance/rice	n/a
Wright	USA	Training Program Follow-Up	4

As detailed above, the projects assigned to the graudate students are, by and large, directed toward basic or pathbreaking research such as developing systems of plant regeneration from anthers, suspensions, and protoplasts. There are also projects to study different stresses and to improve the efficiency of callus tissue culture. These projects have been clearly stated in the 1987 Work Plan. The visible outputs of these types of research are slow in coming due to their speculative nature. Progress has been made in regeneration of rice from suspensions, selection techniques for toxins of rice

blast, rice anther culture, callus formation from protoplasts, correlation of *in vitro* and whole plant tolerance to PEG (drought), and selection for more nitrogen efficient rice.

C.,G. Assess cost-effectiveness of sub-agreements (sub-grants) for (i) equal partner cooperative; (ii) technical support networks; and (iii) pathbreaking research. Obtain and analyze data on sub-grants for (i) strengthning LDC labs (output 10) and (ii) involvement of U.S. universities (output 11) in research, field testing and information exchange.

To date, the Project has funded four sub-agreements, three of which are for pathbreaking research in rice, corn, and wheat tissue culture and one which is for field testing of rice. Three of these agreements are in their second funding years; the corn agreement is in its third. The total dollar amount spent and obligated through December 1988 is $115,896. More than twice this amount was originally budgeted; however, the program was drastically curtailed in January 1986 when AID ascertained that the TCCP was potentially competing with the Science Advisor's program.

Sub-agreements are highly cost effective for two reasons: 1) The cost of labor in developing countries is very reasonable compared with salaries in the U.S. A lab in the Philippines can hire a full-time research associate for about $1700 per year, a fraction of what it would cost the TCCP. The corn program here at the TCCP, for example, was costing an average of $52,335 per year during grant years one through three. Since the program was transferred to ViSCA in 1987, the average cost of the research (per year) for grant years four and five is expected to drop to $15,260; and 2) The labs chosen as recipients have capabilities and expertise that the TCCP does not. For instance, TCCP personnel have had little success with corn regeneration, but Dr. Tuyen's lab in the Philippines has regenerated many plants. Sub-agreements

are also ideal for fulfilling the field testing mandate since it is impossible to test rice, for example, in Colorado.

It should be noted, too, that sub-agreements play an important role in technology transfer. Support through sub-agreements enables labs in developing countires to strengthen their existing tissue culture programs. Collaborators in the Philippines, for instance, are working on crop improvement problems pertinent to that country. ViSCA's research is on corn, specifically white corn used in the Philippines. The field testing for salt-tolerant rice is taking place in an area of the Philippines where saline soil is a major problem. UPLB's research on heat tolerance—a major growth limiting factor—in wheat is using cultivars important to that area. Looking at these agreements purely from a cost efficiency standpoint misses a large part of the non-monetary gain—a gain in experience and knowledge.

The LSU sub-agreement is quite different from those in developing countries in terms of cost. While the Philippine recipients take only 10% of the funds for overhead costs, LSU takes 35%. When the LSU agreement was being negotiated, TCCP management tried in vain to avoid the hefty indirect cost. The Project, after consulting with the AID Project Monitor, decided to grant the funds in spite of this, since it would have cost the Project more in terms of time to get a similar program started here. It should also be noted that the TCCP pays indirect costs (39.9%) to CSU on the first $25,000 of all sub-agreements.

SUBAGREEMENT ACTIVITY

Name	Country	Project	Associated Output
LSU	USA	Somaclonal variation/ rice	1a
UPLB	Philippines	Field testing/rice	2b
UPLB/IPB	Philippines	Heat tolerance/wheat	1b
ViSCA	Philippines	Regeneration/rice	1a

D. Assess the cost effectiveness of Network support activities including publications, information, and personnel exchange.

During the first three years of the Cooperative Agreement, $379,108 was spent on Network activities (6% of total expenditures), $68,737 of which was for travel (including conferences), $156,187 of which went toward personnel support, with the remainder ($154,184) going toward supplies, publications, and indirect costs. Considering the fact that Network outreach has resulted in 10 Memoranda of Agreement, four sub-agreements, a total of 24 graduates of the Training Program, four visiting scientists working on Project-related research (at little or no cost to the Project), and numerous field testing sites in the U.S., Africa, Asia, and Latin America, it is evident that the Network component of the Project has more than fulfilled its original goal.

Currently, there are 976 persons on the TCCP/IPBNet mailing list. For about $388 per person (over three years), we have been able to provide research news and information, literature searches, and funding assistance. Recognizing that, of the 976, 271 are active collaborators with whom we have formal cooperative agreements or who are actively engaged in tissue culture research, the cost per person is actually somewhat higher, or $1399 person (over three years). This cost, however, represents support of some 25 persons to attend

IPBNet conferences, and travel costs associated with Network development and expansion, and technical assistance.

In terms of joint research, work with Chulalongkorn University during Grant Year Two resulted in a publication on the effect of ethylene on rice regeneration in Thailand versus at the TCCP lab in Colorado (in press; Plant Cell Tissue and Organ Culture). In another joint project with CIMMYT, the TCCP supports a full-time employee to work on widecrosses of wheat and its wild relatives. CIMMYT provides cytological facilities and expertise not available at the TCCP, and supplies the necessary research materials. The products of this research will be put into the field this spring.

Current, Active Collaborative Agreements

Institution	Country	Activity	Crop	Output
CATIE	Costa Rica	Regional Training Ctr	Various	4
CIAT	Columbia	Field testing	Rice	2b,3c
CIMMYT	Mexico	Widecrosses	Wheat	SF-1,3c
ICRISAT	India	Regeneration	Chickpea	1b,3c
LSU	USA	Somaclonal variation	Rice	1a,3d
NIAB	Pakistan	Widecrosses	Rice	SF-2,3b
PCARRD	Philippines	Oversee research	Various	3b
UPLB	Philippines	Field testing	Rice	2b,3b
UPLB	Philippines	Stress selection	Wheat	1b,3b
U Arizona	USA	Field Testing	Sorghum	2b,3d
U Georgia	USA	Field Testing	Sorghum	2b,3d
U Nairobi	Kenya	Field Testing	Sorghum, millet	2b,3d
U Saskatchewan	Canada	Field Testing	Oats	2b,3d
ViSCA	Philippines	Regeneration	Corn	1a,3b

In terms of publications and information dissemination, a 2000-copy run of the IPBNet Newsletter costs about $1500, or $.75 per copy; mailing costs about $.35 per copy. So, for just over a dollar per person, the TCCP can relay current research news, advertise job openings, publicize conferences and workshops, and gain interest from more and more scientists. As interest in the Project grows, so does the ability of the TCCP to obtain funds for trainees, conference particpants, and visitors. In terms of direct support, the TCCP has pulled in $348,185 over the last three years from sources other than AID/Washington in support of graduate students, visiting scientists, trainees, and researchers. This amount alone nearly pays for the networking activities. Another $154,526 in indirect support (stipends, salaries) was gained over the three-year period to fund tissue culture research.

E. Assess the success of CSU/TCCP in obtaining the collaboration of IARC's within the network, particularly for (i) supply of germplasm; (ii) field testing; (iii) exchange of information on stresses affecting production expenditure and budget; and (iv) facilitating cooperative programs with network members (no project funds).

Generally the IARC's have been accessible for providing germplasm, but much less so for assisting in field evaluations. Much of the germplasm used to begin <u>in vitro</u> research on each crop within TCCP has been supplied by the international centers.

Lines supplied by IARC during the past 12 months.

Crop	Center	Number of lines
cowpea	IITA	2
pigeon pea	ICRISAT	15
dry bean	CIAT	2
rice	IRRI	15

In terms of field testing the TCCP has initiated a number of interactions with IARC's. CIMMYT is the primary cooperator for the field testing of spring wheat produced at the TCCP. Dr. Mujeeb Kazi is directing both seed increase generations and selection for salt and disease tolerance in CIMMYT plots throughout Mexico. So far seeds from over 460 regenerated wheat plants have been sent to Mexico.

TCCP carried out two generations of field testing of over 400 potentially salt-tolerant rice at IRRI until the plots were destroyed by a typhoon. Because of this and of the large number of people linkages involved in field testing TCCP material at IRRI, current testing is carried out through the University of the Philippines at Los Banos (UPLB).

Rice lines are also being evaluated by CIAT for field tolerance to aluminum. Approximately 75 rice lines were sent to CIAT in May of 1987.

After some negotiations with ICRISAT the TCCP staff decided that the primary field testing site for sorghum should be in the United States where the Project is currently cooperating with the University of Georgia and the University of Arizona.

Field testing locations for legume germplasm are currently under evaluation by TCCP staff and will probably include locations in both Africa and Asia.

F. Obtain and analyze data for cost-effectiveness of outputs and sub-outputs.

Since the Cooperative Agreement is little more than half complete, it is difficult to assess cost-effectiveness for outputs. Once improved germplasm is actually released, it will be possible to look at the cost of achieving the goal through tissue culture. At this point, we can assess the cost of bringing some crops to the field testing stage. Some plants can be assessed only to the

greenhouse phase. Following is a summary of the plants produced and the associated costs.

Cost of Developing Legumes *in vitro* to the Greenhouse (Plantlet) Stage

Crop	# Plantlets	Cost/Plantlet
Soybean	35	$3343*
Pigeonpea	65	$ 85
Moth bean	89	$ 115
Tepary bean	11	$ 16

* AID/Washington ordered termination of soybean research just as full-scale plant production began.

Cost of Developing Stress-Tolerant Plants *in vitro* to the R_1 Generation

Crop	Location	#Lines	#Plants	Purpose	Cost/Plant
Millet	Kansas	13	6000	drought	$47
Wheat	CIMMYT	409	23450	seed increase	$14
Sorghum	Arizona	140	79545	salt	$ 1
Rice	CIAT	35	3500	acid	
Rice	NIAB	73	7300	salt	
Rice	UPLB	407	26455	seed increase	$11 (total)

The figures given above are not accurate because they do not represent the population of plants regenerated. At each stage--regeneration, greenhouse, and field--the number of plants is reduced to a manageable and representative sample. For example, the TCCP's greenhouse capacity is limited, so constraints are placed on the number of plants moved from the lab to the greenhouse.

Private companies assess cost-effectiveness through market analysis. If they are not able to produce a plant via tissue culture cheaper than through plant breeding or propagation and be competitive in the market, then they don't do it. The problem is not quite as simple for the TCCP--a non-profit, federally-funded program. Ultimately, we will be able to compare the cost of producing stress-tolerant plants through tissue culture to the cost of producing them through conventional breeding; however, this cannot take place until the tolerant germplasm is produced and released. It takes two to four years from the time a plant is introduced into the field to insure that the tolerance trait is stable and heritable. The transfer of improved germplasm to farmers in developing countries will then require additional resources.

The cost of basic research must also be taken into account. The figures given above are extremely high because they include research costs from the inception of this Project in August 1980. Once the methodology is worked out and we know that it is possible to produce stress-tolerant seeds, then we will be able to compare those costs with the costs associated with other methods of achieving the same goal.

H. Review pre-requests require for TCCP training courses, evaluation results, and follow-up.

In terms of selection of candidates, the TCCP consulted with AID on priorities and thus arrived at the following criteria: 1) Amount of previous tissue culture experience. The TCCP Training Course is designed for those with little or no experience in tissue culture, thus fulfilling the Project mandate to enable tissue culture research in developing countries; 2) Geographic distribution of applicants. Whenever possible, the selection committee attempts to accept a variety of candidates so that more labs in more countries could be strengthened; 3) Direct assistance to established labs or

organizations. Most applicants accepted should return to tissue culture labs where they can pass on the acquired skills to others, thus reducing their per person training costs; 4) Financial support available. Early on, the TCCP recognized that the Course could become largely self-supporting if sufficiently publicized. Although the first session was largely funded by the TCCP, subsequent sessions have become partially self-supporting. Many training costs (supplies, instructor's salaries, and field trips) are now supported by training fees received from sources such as AID Missions, USDA, Winrock, World Bank, Fulbright, and private and governmental agencies in developing countries; 5) Crop of interest. In-keeping with AID's mandate to help developing countries become self-sufficient in feeding themselves, the candidates chosen have worked on food, and in a few cases economic, crops which are of agricultural and/or monetary importance to the respective countries; and 6) Applicants from countries with AID programs are given first priority for acceptance.

Information on Training Applicants

Session	#Applicants	#Accepted	#Attending
Fall 85	14	8	5
Spring 86	20	12	6
Fall 86	19	12	6
Spring 87	12	8	2
Fall 87	15	10	5
Spring 88	7	7	?
TOTAL	87	57	24

In terms of course development, the TCCP staff planned a basic course that they ascertained would be helpful to the largest number of persons. Through feedback and requests from participants, the Course staff was gradually expanded (with AID approval) to include virus indexing, gene cloning, molecular biology, and germplasm preservation. The TCCP staff will continue to solicit feedback from participants to make needed adjustments in Course content and/or format.

Training Program Topics

Stock solution preparation

Media preparation

Aseptic technique

Suspension/cell culture

In vitro fertilization

Morphogenesis

In vitro stress selection

Virus indexing

Molecular biology

Use of statistics

Research Proposal Preparation

Individual Research to initiate direct technology transfer for crops of interest to home country

Callus culture

Meristem culture

Embryo culture

Somatic Embryogenesis

Protoplast culture and isolation

Anther culture

Germplasm preservation

Laboratory management

Research Seminar Presentation

The TCCP Training Lab has desk space for seven persons. The average size of the sessions has been five trainees. The largest number of applicants accepted was 12. Even though it would be difficult to accomodate a group of that size, experience has shown that many accepted students are unable to

follow-through with their admission due to financial or other difficulties. A group size of five to seven seems ideal for promoting group interaction and discussion, and affords each trainee a maximum amount of individual attention from instructors. This group size also puts less strain on shared facilities such as hoods, benches, and autoclaves.

In terms of cost effectiveness, it should be re-itterated that, for the past two years, the Course has been partially self-supporting. The cost of the Program, per person, is as follows:

Personnel	$4601
Materials	452
Operating Exp	335
Copying	210
Equipment	63
Indirect Costs	2234
TOTAL*	$7895

*Living allowances paid directly to trainees by sponsors are not included in these figures.

Total revenues through February 1988: $40,140

Total cost per trainee : $7,895 x 24 = $189,480 - $40,140 = $149,340 - 2. = $6,225 for six months

Figures are based on FY 1988 Budget for 12 trainees.

The TCCP has found that, by providing partial scholarships of $4400 for tuition and fees, candidates often are able to obtain the balance needed from other sources. This usually enables more persons to attend than if the TCCP agrees to fully fund one or more persons. Obviously, in order to be self-supporting, the TCCP would have to accept a minimum of six, fully-funded trainees per session.

In comparison to other tissue culture courses offered in the U.S., the TCCP Course costs about one-half as much on a per-week basis. In 1986, the University of Tennessee, Knoxville, and the Catholic University of America were offering short courses for $1100 for two weeks and $650 for one week, respectively. The TCCP Program, by contrast, costs about $333 per week ($249 when trainee support from outside in considered). The TCCP's costs are lower because 1) it does not seek to make a profit, and 2) it has a year-round staff that works on research projects in addition to teaching for the Course. Of course, if the number of trainees per session could be increased, the Program would cost the TCCP even less on a per person basis. Current facilities, however, will not allow an increase in class size.

ISSUE 4. MANAGEMENT DIFFICULTIES

AID is concerned that the TCCP is not yet being managed in a way that provides confidence that the grant purpose will be substantially and successfully achieved within the timeframe (five years) and resources being made available. The use of a cooperative agreement in lieu of a contract mechanism implies a close continuing and collaborative mode between CSU and AID which has not yet been fully achieved.

A. Only one Work Plan has been submitted to AID by August 1987, it did [not] dilenate activities by grant year or provide cost estimates by outputs, and proposals for new research subjects were not included or identified as such.

The Cooperative Agreement beginning on page B5 contains Annual Work Plans for years two through five. This Work Plan was expanded considerably into Major Design Elements, Work Plans and Schedules in March, 1985. This document served as the Work Plan for the Project until it was modified in late 1987. The process of revising the Work Plan took six months. After an initial revision of the 1985 Work Plan, AID gave instructions to adopt an entirely different format and also include cost estimates. AID had not requested that

the work plans include cost estimates by outputs until the fall of 1987. This feature was subsequently incorporated into the Revised Work Plan of December, 1987.

B. An annual progress report has been submitted for 8/31/84 to 10/31/85. A second report was submitted in July 1987 which was a cumulative of the TCCP activities during its first five years of existence and progress during the first two years (i.e. until 10/1/86) of the five year cooperative agreement. Besides their tardiness, these reports have not contained the information needed and in a manner to carry out the management functions and processes specified in the agreement and summarized above.

The first annual report was submitted late and might not have provided all of the information necessary for AID "to carry out management functions"; however, AID had not provided guidelines on preparation of such reports. The Cooperative Agreement requirement is to "describe the results of the Plant Tissue Culture research carried out during the year/life of the program." Two months after the report was submitted, AID responded with some general comments and criticisms which were considered in the preparation of subsequent reports. Not until November, 1987 did the TCCP receive any specific reporting guidelines from AID.

The second (Progress) report, completed in May 1987 and published, in color, in July, was of a cumulative nature. During a visit of the AID Project Monitor in March 1987, the Operations Director discussed with him the content and nature of the report, showed him a table of contents, solicited and received suggestions and obtained approval to forego production of a separate, internal-use annual report.

A third report was submitted and accepted before December 31, 1987. This report contained useful management information such as budget and personnel

allocation, an organizational chart, a visitor list, and a list of publications and reports, in addition to technical research information.

C. The MRG has not been established and, with AID de facto, has been relegated to a passive role. TCCP recognition of this "collaborative or partnership" mode vis-a-vis contractor relationship is not demonstrated in the activities and documentation available to date.

Originally, Dr. James Walker, Project Monitor as the Project began, envisioned a Management Review Group (MRG), a Network Review Group (NRG) and a Research Advisory Group (RAG). During the first year of the Project it was realized that three advisory groups entailed an expenditure of too much money and too much time especially considering that the groups were international in their scope of participation.

The MRG first met during the IPBNet Conference in Fort Collins in October 1985 as the Project began its second year. The group consisted of Dr. Tejpal Gill, Dr. Trevor Thorpe (University of Calgary), Dr. Thavorn Vajrabhaya (Chulalongkorn University, Bangkok), and Dr. Irv Asher (Science Advisor's Office, USAID). Also attending the meeting was Mr. George Cox, Project Management Consultant.

During the second year of the Project, it was realized that the MRG was too large, widely-distributed, and busy to have meetings twice a year or even once a year. Following a meeting with Dr. Gill, Project Monitor, in May 1987, the Group was restructured to contain Dr. Nabors, Dr. Gill, and Dr. Meiman at CSU. Considering budget cuts this was considered to be a group of a more effective size which could meet regularly in person or by conference phone call.

In the fall of 1987, a TCCP/CSU Advisory Group was formed to use on-campus expertise to advise the Project and to firmly establish linkages within the CSU community. This Group consists of Dr. James Colbert, Assistant Professor of

Botany, Dr. Robert Heil, Director of CSU Experiment Station, Dr. Marvin Jensen, Director of CSU Irrigation Institute, Dr. James Meiman, Director of International Programs, Dr. John Raich, Dean of Natural Sciences, Dr. Lee Sommers, Chairman of Agronomy, and Dr. Stephen Wallner, Professor of Horticulture. The group is not meant to replace or to function as the MRG.

D. Their is concern by S&T/AGR that not enough time is devoted to managing the TCCP by the CSU Project Director, that there is inadequate delegation in some cases, too much staff turnover, and not enough attention devoted to planning and monitoring collaborative research and field testing.

At Project inception in August 1984, Operations, Research and Network Directors were hired. The Operations Director had an MBA while the other two Directors were completing master's degrees. In 1985 an Associate Director with a Ph.D. was added along with a master's level Training Coordinator. In 1986 a Ph.D. was hired as the new Research Coordinator. From the beginning the Project has employed Greenhouse and Lab Managers. At present, including the Project Director, the Project employs 5 persons with Ph.D.'s, 5 with MS's and one with an MBA.

It seems unlikely that there can be both inadequate time devoted to the Project by the Principal Investigator and inadequate delegation. The organizational structure of the TCCP is designed to spread responsibility for the day-to-day functioning of the Project among a team of managers, coordinators, and directors, each fully competent in his/her own area. This "management team" meets on a weekly basis with the Project Director to discuss research progress, operational difficulties and/or changes, staffing patterns, and policy implementation. The Project Director, while not directly involved in the daily operations of the TCCP, is an integral part of the Management Team, is constantly apprised of progress and problems, and continually monitors

the effectiveness of the management team in pushing the Project to its end goal.

Staff turnover in 1987 has been higher than usual due to a variety of factors. The Project continually wrestles with the problem of having a staff primarily consisting of undergraduate students or recent graduates who use their employment here as a stepping stone before continuing their education or moving on to better-paying employment. We compete with industry positions offering 1.5 - 2 times the salary for equivalent experience. Two of our full-time researchers left this year to seek higher-paying jobs. In addition, two researchers left in August to pursue graduate education. We are replacing only two of these four persons to allow for higher salary levels for the remaining research staff. Salary levels must be raised if we are to be able to attract and retain qualified, dedicated researchers.

E. No information (see also Issue 3) is provided on mission buy-ins and how they contribute to producing outputs and achieving the Project purpose.

Heretofore, the Project has not had direct Mission buy-ins; however, there have been numerous buy-ins with respect to trainees and visiting scientists supported, as detailed below.

Activities at the TCCP Supported by AID Missions

Name	Country	Activity	Duration	Amount/Type
Gothwal	India	Training	6 months	$8,000 plus transportation
Hassan	Jordan	Training	6 months	$8,000 plus transportation
Hidayat	Indonesia	Training	6 months	$5,400 plus transportation
Javier	Philippines	Training	6 months	$3,900 plus transportation
John	Pakistan	Graduate Education	3 years	$8,640/year plus tuition & transportation
Karihaloo	India	Conference	1 week	$600 plus transportation
Kartapradja	Indonesia	Training	6 months	$5,400 plus transportation
Kokoa	New Guinea (Fiji)	Conference	1 week	$100, per diem, transportation
Krishnamurthi	Fiji	Conference	1 week	$100, per diem, transportation
Raina	India	Conference	1 week	$600 plus transportation
Ruabete	Fiji	Training	6 months	$8,000 plus transportation
Zafar	Pakistan	Research	16 months	$16,000 plus transportation
Total				$64,777 plus transportation and tuition (approx. $20,000)

Buy-ins from sources other than Missions are discussed in the "Additional Data" section.

Cooperation from Missions has been inconsistent and unpredictable. The support or lack thereof from Missions seems to depend largely on the Director. For example, on Tom Dykes' visit to Sri Lanka in 1985, the Mission was very negative toward supplying funds or any other support and discouraged Mr. Dykes from building expectations of scientists in Sri Lanka. This attitude has basically prevented any collaboration with Sri Lanka.

The Missions listed above, along with those in Thailand, Kenya, and Bangladesh, have been particularly helpful in arranging meetings with local scientists, and providing support, directly or indirectly, for collaborative research, training, travel, and conferences. These kinds of "buy-ins" contribute directly to Project goal achievement by strengthening IPBNet. It has been found that gaining support, financial or otherwise, from the Missions is crucial to success in any particular country. The Missions can, in many cases, influence the course of collaboration with cooperating organizations. Funding is a major constraint. More important is the Mission's decision to ally itself with IPBNet and support its efforts.

F. Progress reporting on research has been over-technical in content and in some cases difficult to relate to approved sub outputs and funding allocations. Reporting on other outputs has been spotty and incomplete.

Project reporting falls into three different categories:

a. Technical. This consists of papers in referred scientific journals, technical bulletins, technical notes in the Project Newsletter, and technical posters and presentations at scientific meetings.

b. Non-technical. This consists of Project Newsletters, Progress Reports, Papers presented at some international conferences, and verbal presentations to various groups.

c. Output related. This consists primarily of the Revised Work Plan of December 1987 and Annual Reports. Recently, AID has also requested Quarterly Reports.

Only the third category of reporting should be directly keyed to Project Outputs. The formats for both Quarterly and Annual Reports have recently been agreed on by AID and CSU. They should supply Project management in both Washington and Fort Collins with the information needed to monitor progress as it relates specifically to Outputs of the Work Plan and to the Cooperative Agreement. (See Issue 4b for more information on reporting.)

ADDITIONAL DATA

1. Prepare a network matrix with 3 parameters.

See page 23, Issue 3d.

2. Prepare a financial analysis by output for 1980 - 1989.

Budget Summary (Aid Funds only)

1975 AID Grant	$ 25,000
1980 AID Contract	929,982
1984-1986 Cooperative Agreement (CA)	2,727,000
1987/88 CA (Projected)	966,430
1988/89 CA (Projected)	942,991
TOTAL	$5,218,452

BUDGET BREAKDOWN FOR AID CONTRACT NO. 0273, 1980 - 1984*

	Person Years	Cost for 1981
1. Set-up lab	.6	$ 8,918
2. Prepare guidelines	.9	13,377
3. Establish cell lines of wheat, rice, millet, oats	7.5	111,476
4. Screen wheat/NaCl	3.1	46,077
5. Regenerate wheat	1.5	22,295
6. Screen additional wheat varieties/NaCl	0	0
7. Screen wheat/Al^+, drought	0	0
8. Compile Bibliography	.4	5,945
TOTAL	14.0	$208,088

	Person Years	Cost for 19^2
1. Obtain NaCl or Al^+ tolerant lines of rice, millet, oats	12.8	$151,069
2. Greenhouse test NaCl - tolerant wheat	0	0
3. Regenerate whe	1.2	14,163
TOTAL	14.0	$165,232

	Person Years	Cost for 1983
1. Regenerate rice, millet, oats	6.5	$ 80,392
2. Greenhouse test tolerant wheat	0	0
3. Field test wheat	0	0
4. Improve wheat screening	9.5	$117,496
TOTAL	16.0	$197,888

*Figures include $5,000 per year from CSU Experiment Station for oats research. See yearly budgets, attached.

	Person Years	Cost for 1984
1. Regenerate & greenhouse test tolerant rice, wheat, millet, oats	18.1	$204,215
2. Field test wheat or rice	0	0
3. Continue greenhouse testing	0	0
4. Personnel Exchange	1.5	16,925
5. Attend Conferences	.4	4,513
Total	20.0	$225,653

BUDGET BREAKDOWN FOR COOPERATIVE AGREEMENT GRANT YEARS 1 - 3*

	Person Years and Cost					
A. Research and Development	1985		1986		1987	
1. Output 1: Mutant Selec. and Pl. Regen. (Total)	21.4	$624,816	20.5	$675,027	24.85	$743,132
1a. Regeneration	10.6	309,488	9.8	322,696	9.5	284,095
1b. Stress Selection	7.4	216,058	6.[illegible]	197,569	8.3	248,209
1c. Widecrosses	.8	23,358	1.[illegible]	39,514	1.1	32,895
1d. Nitrate Reductase	.5	14,599	.5	16,464	.5	14,952
1e. Protoplast Regen.	1.8	52,554	2.7	88,906	2.55	76,257
1f. Cloning	.3	8,759	.3	9,878	2.9	86,724
2. Output 2: Verification of Tolerance (Total)	.7	$20,438	1.6	$54,331	3.8	$113,638
2a. Greenhouse Testing	.7	20,438	.6	21,403	1.8	53,828
2b. Field Testing	0.0	0	1.0	32,928	2.0	59,809
2c. Seed distribution	0.0	0	0.0	0	0.0	0

202

B. IPBNet

1. Output 3:

Network Core Creation (Total)	1.5	$43,796	2.7	$88,906	1.0	29,905
Major Activities:						
Establish & Expand IPBNet	.6	17,519	1.2	39,514	.2	5,981
Maintain & Expand Comp File	.2	5,839	.5	16,464	.3	8,971
Establish & Coordinate Conference	.5	14,599	.5	16,464	.2	5,981
Provide Tech. Assistance	.2	5,839	.5	16,464	.3	8,971

2. Output 4:

Training Program (Total)	1.0	29,197	1.9	62,563	3.6	107,657
Major Activities:						
Course Preparation & Implementation	.5	14,599	.5	16,464	2.0	59,809
Publicity & Selection	.4	11,679	.9	29,635	1.0	29,905
Follow-up	.1	2,919	.5	16,464	.6	17,943

*Budgets include funds from other sources. See detailed budgets, attached.

	Person Years and Cost					
B. IPBNet (continued)	1985		1986		1987	
3. Output 5:						
DC Collaborations (Total)	.4	11,679	1.2	39,514	.2	5,981
Major Activity:						
Facilitate & Monitor Relationships	.4	11,679	1.2	39,514	.2	5,981

4. Output 6:						
Info & Personnel Exchange						
(Total)	.3	8,759	.5	16,464	.6	17,943
5. Output 7:						
Facilitate Coop. Res.						
(Total)	.1	2,919	.3	9,878	.2	5,981
6. Output 8:						
Field Testing TCCP Crops						
(Total)	.1	2,919	.5	16,464	.7	20,933
7. Output 9:						
IARC Collaboration (Total)	.5	14,599	1.0	32,928	.5	14,952
Major Activity:						
Establish Agreements	.5	14,599	1.0	32,928	.5	14,952
8. Output 10:						
Sub-grants (Total)	0.0	0	.6	19,757	.3	8,971
Major Activity:						
Esta' lish Agreements	0.0	0	.6	1[illegible],757	.3	8,971
9. Outp[illegible]. 11:						
U.S. Collaboration (Total)	0.0	[illegible]	.4	13,171	.5	14,952
Major Activity:						
Establish Agreements	0.0	0	.4	13,171	.5	14,952
TOTAL	26.0	759,121	31.25	1,029,003	36.25	1,084,045

3. Provide information on the use of sub-grants and relate to relevant output or sub-output. Include information about how and when approved, purpose, monitoring of activities by TCCP, and expected/actual results

Originally, the Project advertised its sub-grant program in the IPBnet Newsletter. From this single announcement in January 1986, the Project

received about 20 applications. Soon after, however, the program was sharply curtailed (see Issues 3c & g). Before that time, two sub-grant recipients had already been identified and funding approved. Proposals from Dr. Nguyen Tuyen of ViSCA and Dr. M. C. Rush of LSU were reviewed by the TCCP Management Team and the AID Project Monitor, and were funded in January and August 1986 respectively. The sub-grants were awarded for research directly related to Project outputs (see Issues 3c & g).

The sub-grants are monitored through quarterly and annual reports, and through regular visits by Project personnel. Results of the four current sub-grants are in the 1987 Annual Report (pp 34-42, 76-79) and are briefly described below.

Dr. Tuyen's research was to develop plant regeneration techniques for corn and rice. In corn she has used several lines developed at ViSCA and has been able to obtain plant regeneration up to 5 months. Plants which were regenerated and grown to maturity had various phenotypic mutations which are typical of R_0 corn plants. Dr. Tuyen's rice work has been to modify TCCP's procedures to her conditions and cultivars of upland rice. At TCCP we use rice cultivars developed for flooded patty conditions.

Dr. Rush at LSU has developed an alternate plant regeneration system using immature panicles. From his field evaluation of regenerate lines he observed that somaclonal variation was cultivar-dependent. He has since studied <u>in vitro</u> mutagenesis to enhance the development of somaclonal variants. Dr. Rush also investigated shipments of <u>in vitro</u> plants to IITA and IRRI with good success.

The high temperature selection of wheat project in Dr. Zamora's lab has been modifying TCCP's procedures to their cultivars and conditions which

include high temperatures in the growth room. They are beginning to see success in the plant regeneration experiments.

The field evaluation sub-grant with UPLB (Dr. Hernandez) is in it's second saline evaluation season. In the current test there are over 1800 lots on R_2 and R_3 lines being evaluated.

4. Describe meeting panels, seminars, etc., sponsored or funded by TCCP, including purpose and results of each mission buy-in.

Meeting Panels. Panel discussions are a regular part of the IPBNet conferences. During the first conference in Fort Collins in 1985, there were panels, as listed below, on scientific subjects.

	Title	Moderator
1.	Tissue Culture Biotechnologies of Tropical Crops	Dr. Abraham Krikorian, New York University, Stony Brook Dr. Ludwig Muller, CATIE
2.	International Agricultural Research Centers - Their Missions and how to Cooperate with Them	Dr. William Roca, CIAT Dr. D. S. Brar, IRRI
3.	Agency for International Development (AID) Information - Obtaining Science Adviser's Grants	Dr. Irvin Asher Dr. Tejpal Gill, USAID
4.	Cell Genetic Manipulation	Dr. Oluf Gamborg, TCCP Dr. Trevor Thorpe, University of Calgary

The conferences also serve to facilitate information exchange and develop new ideas for improving communication and the efficiency of the IPBNet functions.

To facilitate this process each conference has smaller group discussion sessions. All of the participants are divided into groups, each with a

moderator. The participants then present in writing suggestions and recommendations which are used as guides to improve the IPBNet functions.

Seminars sponsored by TCCP are held at TCCP or on the campus. Most visitors to TCCP fall into one of two categories. Some visitors come because they are interested in the activities of the Project. Other visitors are potential or active collaborators. A few of the members of the latter group are TCCP-funded and all of these present a seminar. The visit also includes a planning discussion.

Below is a list of visitors who presented seminars during the past two years.

Name	Affiliation	Topic
Dr. Christine Alang	Malaysia	Palm tissue culture
Mr. Marco Giacchiro	International Development, Fiatagri	International Agriculture Development, Asia, Africa
Dr. Robert Conger	University of Tennessee	Tissue culture of grasses
Dr. S. C. Gupta	University of New Delhi	Tissue culture of legume trees
Dr. Hans J. Jacobson	Bonn University	Plant regeneration in pea
Dr. Hu Han	Genetic Institute, Beijing	Anther culture in plant breeding
Dr. K. Ojima	Tokyo University, Japan	Aluminum tolerance in rice tissue culture
Dr. Yusuf Zafar	NIAB, Faisalabad, Pakistan	Tissue culture of salt tolerant grass species
Dr. Gary Hanning	University of Nebraska	Tissue culture of grasses and soybean
Dr. A. Mujeeb-Kazi	CIMMYT	Hybridization of wheat and other species

Dr. Charles Sullivan	USDA/ARS, University of Nebraska	Sorghum breeding for drought tolerance
Dr. R. B. Clark	USDA/ARS, University of Nebraska	Sorghum physiology in relation to mineral stress
Dr. David Sands	Montana State	Biological pest control

Visitors who presented seminars (continued):

Name	Affiliation	Topic
Dr. Suresh Patil	University of Hawaii	Tissue culture screening
Dr. Supat Attathom	Director, Kamphaensaeng, Campus, Bangkok	Crop plant biotechnology in Thailand

The seminars provide new information and personal contact with scientists from LDC's and North America. The topics are usually of mutual interest. Since the TCCP has become one of the leading centers worldwide on the use of plant biotechnology applied to stress tolerance, the interest in the research continues to grow.

5. Describe any contributions to or use of TCCP capabilities by other donors or clients.

TCCP makes significant contributions in two principal categories. They comprise the direct transfer of new technologies and the transfer of information and technology through consulting. The direct transfer of technologies are mediated through the Training Course, through shorter visits and through arrangements where visiting scientists work at TCCP for several months. The latter are often collaborative projects. For details see Issues 3 and 4 or Annual Report 1987.

Several specific examples of direct technology transfer include the following:

Ms. Kerri Wright spent one year at Chulalongkorn University in Bangkok performing rice tissue culture.

Ms. Julie Cotton spent six months at University of Philippines where she initiated work on wheat tissue culture and heat stress selection.

Ms. Nitschka ter Kuile has been at CIMMYT, Mexico since 1985 working on widecrosses and tissue culture in wheat.

Papers based on TCCP research have been presented at several conferences and workshops where the sponsoring agency provided financial assistance or the event coincided with visits to collaborating institutions in the particular and neighboring countries. Examples of such are:

1. Seminar on IARC an Biotechnology, Los Banos, 1984 (Nabors)
2. IRRI - International, Rice genetics symposium, 1985 (Nabors)
3. Biosaline Research Workshop, Karachi, 1985 (Gamborg)
4. Biotechnology in Agriculture International Workshop, New Delhi, 1985 (Gamborg)
5. Project Design Workshop for Rice Collaborative Research, IRRI, 1986 (Gamborg)
6. Biotechnology for Developing Countries, INTSOMIL, Kansas City, 1987 (Hanning)

Technology and information is transfer ed to several hundred persons worldwide who receive the TCCP Newsletter, reports, and research publications. Details can be found in the 1987 Progress Report and the 1987 Annual Report.

Individuals at TCCP are often approached and invited to serve as consultants, advisors or specialists in projects within less developed countries. One of the major assignments was in Thailand in 1986. The consulting was for the National Center for Genetic Engineering and Biotechnology (NCGEB) of the University of Science, Technology and Energy, Thailand. The agreement was handled by BOSTID of the National Academy of Sciences for USAID/Bangkok.

Dr. O. Gamborg and Dr. M. Nabors prepared a Report with specific recommendations entitled: A Plant Tissue Culture Biotechnology Network for Thailand and for Support Towards Identified Tissue Culture Projects, Plant Species, Goals and Locations in Thailand" June, 1986, 65 pp. The document contained detailed proposals for 13 research projects. Each project contained specific research objectives in specified crops and institutions. The Government of Thailand has approved funding for five of the proposals and is considering financial support for several others. Dr. Gamborg and/or Dr. Nabors are advisors on each of the funded projects. Invitations for consulting in Biotechnology have also been received from agencies in Indonesia, Kuwait and India. We have also been approached to arrange and participate in workshops. The invitations are rarely accepted since time and especially funding are not allocated for such activities within the Cooperative Agreement.

During the period of consulting in Thailand in March 1986 the NCGEB sponsored a symposium on protoplasts technology. Dr. Gamborg participated as organizer and lecturer. Dr. Christy MacKinnon and Mr. Raymond E. B. Ketchum from TCCP also participated as lecturers and instructors in practical sessions. The symposium was held in Bangkok and financial support was provided by USAID and the Ministry of Agriculture of Thailand.

6. Describe how the TCCP has resulted in the expansion of CSU capabilities and involvement in plant biotechnology as related to LDC problems.

TCCP has established collaboration with several departments on the CSU campus. The liaison has evolved as staff from TCCP approached CSU personnel who have expertise and interest which complemented TCCP programs and objectives.

Below is a list of CSU personnel and the areas in which they are involved. The collaborations involve graduate students, participation in the TCCP Training Course, or the use of facilities. The best example of the use of

-210-

facilities is the collaborative program with Dr. Colbert. All of the research involving molecular biological procedures is performed in Dr. Colbert's laboratory. TCCP has provided funds for supplies and materials.

Investigator and Department	Program of Collaboration
Biology/Botany	
Dr. James T. Colbert	(a) Molecular Biology One graduate student USAID/Pak supported (b) Instructor in Training Course
Horticulture	
Dr. Harrison Hughes	(a) Instructor in Training Course (b) Independent study student (c) Graduate Student Committee
Agronomy	
Dr. Duane L. Johnson	(a) Plant Breeding One graduate student USAID/Pak supported (b) Graduate Student Committee
Dr. Mark A. Brick	(a) Plant Breeding Collaborator in grain legumes
Dr. James S. Quick	(a) Plant Breeding Collaborator in drought tolerant wheat
Plant Pathology	
Dr. Clark Livingston (retired)	(a) Instructor in Training Course
Dr. Howard F. Schwartz	(a) Plant Pathology Collaborator in grain legumes

USDA/ARS

Dr. Leigh Towill (a) Instructor in Training Course

These collaborations and affiliations with the University staff have resulted in strengthening programs in the respective Departments and in the TCCP. As an example, the molecular biology program is carried out with essential contributions from both the TCCP and the Biology Department.

University staff members have also served an essential function as instructors for the Training Course. The TCCP staff alone could not adequately provide the necessary hands-on technology in some areas which are significant, but not a part of the TCCP research. Examples are the topics of micropropagation and the production of virus-free stock plants.

TCCP also has been represented on the CSU Affinity Group in Plant Biotechnology. The group had epresentation from Departments and laboratories which have programs in plant science.

The following staff were included in the discussion and preparation of a report to Dr. Judson M. Harper, Vice President for Research, CSU. The Report was entitled "Biotechnology for Improved Plant Performance under Stress," and was submitted July 28, 1987.

Colorado State University Staff on the CSU Affinity Group in Plant Biotechnology:

Staff Member	Department
Baker, Ralph	Plant Pathology and Weed Science
Bauer, Penelope Hanchey	Plant Pathology and Weed Science
Bjostad, Lou	Entomology
Brick, Mark	Agronomy
Colbert, James	Biology (Botany)
Cuany, Robin	Agronomy

Doxtader, Kenneth	Agronomy
Fechner, Gilbert	Forest and Wood Sciences
Hendrix, John	Biology (Botany)
Hughes, Harrison	Horticulture
Johnson, Duane	Agronomy
Lee, Chi Won	Horticulture
Nabors, Murray/Gamborg, Oluf	Biology (Botany)
Orr, Gregory	Plant Pathology and Weed Science
Quick, James	Agronomy
Roberts, Elaine	Entomology
Ross, Cleon	Biology (Botany)
Schenck, Craig	Biochemistry
Smith, Danny	Agronomy
Stack, Stephen	Biology (Botany)
Trlica, M. Joseph	Range Science
Tsuchiya, Takuma	Agronomy
Wallner, Stephen	Horticulture