PN-ABC-804

EVALUATION OF A SHORT TERM TISSUE CULTURE TRAINING COURSE

Submitted by

Kerri L. Wright
Agronomy Department
in conjunction with the
Tissue Culture for Crops Project (TCCP)
Biology/Botany Department

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State University
Fort Collins, Colorado
Spring 1989

EVALUATION OF A SHORT TERM TISSUE CULTURE TRAINING COURSE

Submitted by

Kerri L. Wright
Agronomy Department
in conjunction with the
Tissue Culture for Crops Project (TCCP)
Biology/Botany Department

In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado State University
Fort Collins, Colorado
Spring 1989

Acknowledgments

I would like to express my thanks to my co-advisors and committee members Dr. John Shannahan, Dr. Murray Nabors, Dr. Duane Johnson and especially Dr. Frank Santopolo who provided the technical expertise in training program follow-up for this study.

Special thanks to Dr. Gary Hanning for several hours of assistance with computer graphics design. Thanks to Ms. Sunitha Siriwardana for providing necessary training background information, and to Ms. Kim Spitler-Nabors and Ms. Susan Sidinger for typing and editing assistance.

This study was supported by the Tissue Culture for Crops Project, a centrally funded program of the U.S. Agency for International Development implemented by Colorado State University under Cooperative Agreement No. DAN-4137-A-00-4053-00.

Table of Contents

Introduction.....1

The Course.....6

Background and Methodology.....8

Objectives.....8

Methods and Procedures.....8

Background Characteristics of TCCP Trainees.....10

Geographic Origin and Gender.....10

Age.....10

Figure 1. Geographic Distribution of Training Respondents....11

Education.....12

Table 1. Age Distribution.....13

Table 2. Education Background and Distribution.....13

Financial Support.....14

Figure 2. Sources of Financial Support.....15

Pre-Training Career Information and Research Background.....17

Training Background Information.....17

Figure 3. Training Background Information.....18

Post-Training Information and Course Evaluation.....20

Training Application.....20

Job Responsibilities and Changes Due to Training.....20

Figure 4. Training Application After Returning to Home Countries.....21

Figure 5. Job Responsibilities and Changes Due to Training...22

Additional Training Information.....23

Figure 6. Additional Training Information.....25

TCCP Course Evaluation.....27

Figure 7. TCCP Course Evaluation.....28

Evaluation of the TCCP Training Experience.....29

Summary and Conclusions.....33

Recommendations for Future TCCP Training Programs.....36

Literature Cited.....39

Additional Resources Contacted.....41

Appendix A. Post-Training Questionnaire.....42

Appendix B. Course Content and Outline.....46

Appendix C. TCCP Course Participant Respondents.....48

Introduction

A Gene Revolution, referred to as a second Green Revolution, is well underway in lesser developed countries (LDC's) and developed countries. It holds the potential answers to higher productivity for crops grown on marginal land under various environmental and ecological constraints (Smuckler et al., 1988). The emerging role of plant biotechnology in international development will cause future changes in the development of policy and programs on national as well as international levels. These changes are already being discussed and debated in virtually all areas of scientific and socio-economic study (Buttel et al., 1985; Plucknett et al., 1987; Sigurbjornsson, 1985). Although research in plant biotechnology exists in developed countries and LDC's alike, the primary area of research concentration and the financial resources are located in the more affluent countries, leaving a growing gap between scientific "haves" and "have-nots."

The LDC's comprise over two-thirds of the world population, but they represent only 13 percent of the scientific community. This disparity contributes to a country's inability to produce income, causing the gap to widen further. A recent study from the Center for Advanced Study of International Development at Michigan State University cites the growing gap in science and technology as being responsible for a large portion of the income gap between the developed and the lesser developed countries (Smuckler et al., 1988). Consequently, the developing nations seek the means of attaining the scientific knowledge as well as the various technologies currently held by the public and private sectors in the developed countries

(Cohen et al., 1988).

One method to overcome the obstacles alluded to here is to assist in developing indigenous biotechnology capabilities (Dembo et al., 1987). The race for research developments in crop improvement is closely monitored by scientists in both Northern and Southern Hemispheres. The Green Revolution and the assorted social impacts associated with it offer lessons applicable to future agricultural development. Current readers of discussions on the impacts of biotechnology are cautioned not to lean towards a new technological development which is void of sociological thought (Ruivenkamp, 1987). Rather, multifaceted programs drawing from a wide range of interdisciplinary expertise are needed. Scientists participating in symposiums such as the one held in San Jose, Costa Rica, in 1985 on "Biotechnology in the Americas II: Applications in Tropical Agriculture" concluded:

> "...A sound program in biotechnology will require the building of a strong capacity in the biomedical and agricultural science. New scientists must be trained and they must be involved in teaching and graduate training as well as in research. It would be a disaster if new biotechnology programs were developed at the expense of current agricultural and forestry research programs..."
> (Panel discussion, Symposium Proceedings, 1986)

The goal of integrating participant training into agriculture programs has been pursued for many years. Yet, training program follow-ups and evaluations have taken place on a limited basis, primarily due to the difficulties involved in obtaining information from sufficient numbers of trainees once they return to their home countries. Training in plant biotechnology, specifically in the area of tissue culture, is relatively new to agricultural development. Thus, systematic follow-ups to such training courses is almost non-

existent. This study reports on one attempt to develop indigenous biotechnology capabilities. Capabilities which include a follow-up survey of its graduates.

The guidelines established by agricultural training follow-up reports published by the consultative Group on International Agricultural Research (CGIAR), UN Food and Agriculture Organization (FAO), United Nations Development Program (UNDP), and the U.S. Agency for International Development (USAID) served as models for this study. One report, published by the Technical Advisory Committee (TAC) of the CGIAR offers the most exhaustive and well documented study in training follow-up undertaken by the various International Agricultural Research Centers (IARCs). The authors conclude that a high priority must be given to increasing national agricultural research capability, in which training plays an important part (TAC Secretariat, 1986).

An important consideration in the LDC's is the extent to which training is directly integrated into existing programs and provides a productive impact at the grassroots level. This assumption provided the basis for a study by the FAO in 1980, entitled "Agricultural Training: Report of an Evaluation Study" which recommends that a clear plan for follow-up should be established at the time of course preparation to assure training will be used effectively (FAO, 1980).

Over the last several decades USAID has contributed to the support of a large number of agricultural training programs. A recent review of participant training evaluation studies sponsored by USAID acknowledged that the need for improved follow-up and contact with returned trainees ranked as one of the most frequently cited issues during the past thirty years (Moser and Elmer, 1986). Several of the studies listed in the USAID annotated bibliography of participant

training evaluations recommend follow-up activities should be increased (Elmer and Moser, 1986a). Although greater emphasis is currently being placed on more substantial follow-up studies, implementation is scarce.

Short-term, technical (non-degree) training programs cover a wide variety of topics in the agricultural sciences. However, available studies and evaluations of these training programs primarily focus on an overview of the course, the background of course participants, actual course content, and often a distribution of financial donors contributing to the course support (USDA Technical Short Courses Annual Report, 1987). The reports on tissue culture courses provide course summaries with similar technical and demographic information (Thorpe, 1981). Although follow-up activities are considered a form of continuing education (USAID Handbook #10, 1981), few courses evaluate the trainees after the actual course ends.

An opportunity to become involved in tissue culture training was presented to the USAID-funded Tissue Culture for Crops Project (TCCP) at Colorado State University in 1984. The Project proposal included several aspects of plant tissue culture: research, information dissemination, technical assistance, and <u>training</u>. The formation of TCCP's International Plant Biotechnology Network (IPBNet) also served as the catalyst for a training program, because Network members were identified from existing USAID Missions, IARCs, and national agricultural research programs and potential training participants were chosen from those identified.

TCCP is a centrally-funded project and is designed and managed by the AID's Bureau for Science and Technology. Training is viewed as

"...not an end of itself, but a means of achieving the project's objective: attainment by the targeted U.S. or developing country organization of the institutional capability to respond to development issues. Funds for participant training are generally built into the project, but Missions and host countries are expected to contribute financially, frequently by covering international travel costs and sometimes the living allowances of participants" (Elmer and Moser, 1986b).

With this concept of training in mind, TCCP laid the ground work for the Training Course (hereafter referred to as the Course) with the following goals: "Establish a plant biotechnology training center located at CSU and implement training courses. These courses will be targeted at enhancing the capability of LDC personnel to utilize a wide range of plant biotechnologies, with emphasis on tissue culture techniques required to solve local (LDC) problems involving crop production" (TCCP Cooperative Agreement, 1984). In this manner the connecting link between developed and developing countries can be realized. The opportunity to transfer biotechnology, termed a "knowledge-intensive" science into "low-tech" biotechnology solutions becomes applicable to the problems of underdevelopment (Kenney, 1987). The involvement of the University in such programs provides a relatively neutral environment for the exchange and free flow of information.

The LDC's desiring access to non-competitive scientific environments will continue to require strong linkages with academic institutions in the developed countries. The training program established at CSU provides the LDC's one way of achieving this goal. This report describes an evaluation of the CSU/TCCP training program.

The Course

The six month training course is held bi-annually at Colorado State University. One session runs February through August with the next session immediately following. The first six weeks consist of lecture and laboratory exercises divided into morning and afternoon sessions, respectively. The topics (see Appendix B) range from basic stock solution preparation, media preparation and callus culture, to more advanced topics such as *in vitro* selection for stress tolerance and anther culture techniques. Through the duration of the Course guest lecturers present a series of special topics including molecular biology, germplasm preservation and the use of statistics in tissue culture.

By the fourth week, the trainees begin preparing research proposals for individual programs which are scheduled to begin the end of the sixth week and last the remainder of the Course. The research projects are designed by the trainees to accommodate special research topics or solve problems specific to their region. Although TCCP specializes in cereal and grain legume research, material has been brought to the U.S. for research on additional crops such as cassava, potato, tea, banana, lentils and peanuts. Project topics are as equally diverse. Due to the predominantly basic nature of the Course, most projects have focused on meristem culture for virus eradication, protocol for regeneration from callus culture, and *in vitro* selection for drought, salt and aluminum tolerance in primarily cereal crops.

Course instructors are from Colorado State University and include:

Dr. Oluf Gamborg, Department of Biology (TCCP)

Dr. Gary Hanning, Department of Biology (TCCP)

Dr. Harrison Hughes, Department of Horticulture

Dr. Clark Livingston, Department of Plant Pathology and Weed Science

Ms. Sunitha Siriwardana, Department of Biology (TCCP)

Dr. Leigh Towill, Department of Horticulture/USDA

Background and Methodology

Objectives

In general the purpose of this study was to evaluate the TCCP course by surveying the participants after they returned to their countries. More specifically the objectives were to:

- Obtain post-training information from LDC trainees, including their suggestions for course improvement.
- Assess the practical applications of training upon return to home countries, further dissemination of course techniques and future training prospects.
- Provide recommendations for continued course evaluation and strengthening of TCCP/IPBNet programs.

Methods and Procedures

In May 1988, questionnaires were sent to the 24 graduates of the six-month TCCP training course. By August the total number of graduates was 28. A second mailing was sent in July and a third in September to ensure a high return. By late October, 1988, 25 questionnaires were returned out of a total number of 28 mailed, representing 89 percent of the graduated trainees. Percent comparisons were used to analyze the returns due to the lack of sufficient data necessary for a multiple correlation analysis (Zeisel, 1966, Chapter One). Although the sample size is relatively small, this study focuses on the feedback of actual course participants, thus the 89 percent return rate is considered acceptable.

The questionnaire was designed to obtain both pre-training and post-training information (see Appendix A). Upon completion of course work at TCCP, Sunitha Siriwardana, Training Coordinator, administered

a course evaluation questionnaire covering specific techniques and course structure items including lecture material and laboratory exercises for her personal knowledge and possible course follow-up. The survey reported in this study, therefore, did not seek similar basic course information but rather asked for pre-training career and research knowledge which could be used in a comparative analysis of post-training reactions. The post-training course information included the extent to which training had been implemented and ultimately disseminated in home countries. The trainees also were asked to assess the benefits acquired as a result of the TCCP training. The final question solicited suggestions for improving future courses and course follow-ups.

Background Characteristics of TCCP Trainees

Before evaluative findings are discussed, the participants' geographic origin, gender, age distribution, educational background, and financial support will be summarized.

Geographic Origin and Gender

The 28 trainees to date represent 14 countries. The largest geographic region represented in the training program, and proportionate in the survey response, is Southeast Asia and the Pacific (Figure 1). A total of ten trainees from Thailand, Malaysia, the Philippines, Indonesia and the Fiji Islands participated. Greater Asia and the Middle East represent five respondents; from India, Pakistan, and Saudi Arabia. An equal number of trainees from the African countries of Morocco, Zimbabwe and Kenya also responded. The region of Middle America is represented by four trainees from Mexico and Guatemala, collectively. Although there is no universal standard definition for Middle America, the term is most often used in reference to Mexico, Central America and the West Indies (West and Augelli, 1976). The final region, Europe, consisted of one trainee from Bulgaria.

Of the total trainees 57 percent were females and 43 percent males. From the 25 survey respondents, 11 countries were represented and 56 percent were females and 44 percent males.

Age

The age of respondents ranged from 24 to 50 years (Table 1). The average age of females was 33.4 years and males 34.3 years. Southeast Asia/Pacific respondents represented the oldest group, with an average of 36.7 years and Middle America the youngest, with an average of 28.3

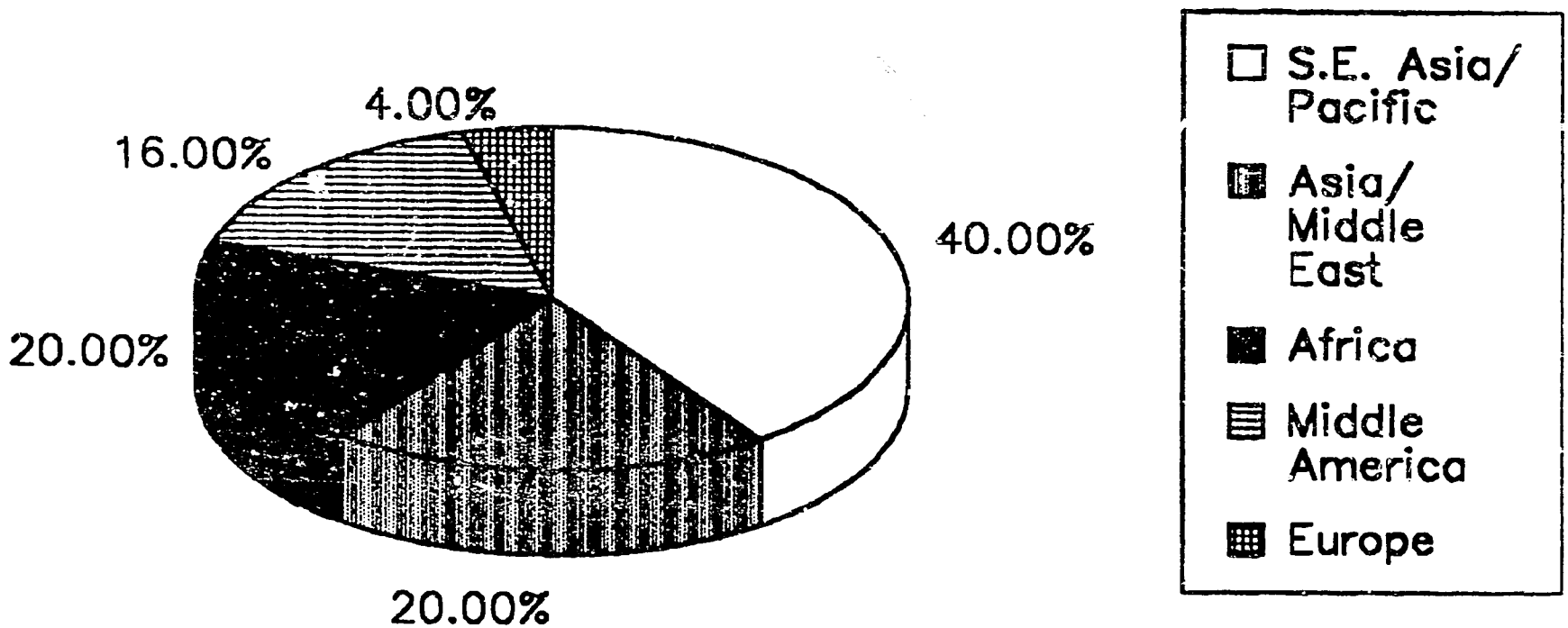

Figure 1. Geographic Distribution of Training Respondents

years.

Education

The educational data were gathered from existing files on preliminary course information. The level of formal education prior to the training at CSU may not be as relevant in this study since Ph.D.'s as well as technical assistants often began at the same level of tissue culture expertise. However, the distribution of prior education is important when using this information as a means to gauge pre- and post-career placement, and ultimate technology transfer. The extent trainees are able to apply their training upon returning to their countries is often directly related to their previous education.

Forty percent of the respondents held a bachelor's degree only (Table 2). The trainees from Southeast Asia/Pacific region held the greatest number of M.S. level degrees with 12 percent of the total. A total of five trainees (20 percent) held Ph.D.'s. Four of the five were female. Those trainees who had not received a formal university degree or diploma represented 16 percent of the total.

The Course requirements did not include rigorous English standards. It was suggested that 550 on the TOEFL exam be required, (CSU graduate school requirements) but not all participants met this qualification. Two trainees enrolled in intensive English courses in preparation for graduate studies, but this alternative was self-imposed and separate from the short-course requirements. The primary means of selecting participants was determined by the written course application. The small size of the course sessions (maximum of five to six) provided more intensive and individual attention for those with a possible language handicap. Apparently language was not a

serious handicap. All the trainees presented project proposals written in English for individual research projects as required.

Table 1. Age distribution.

Range: 24 to 50 years
Average age: 33.8 years

Region	Mean Age (years)
Southeast Asia/Pacific	36.7
Asia/Middle East	35.4
Africa	31.6
Middle America	28.3
Europe	30.0

Table 2. Education background and distribution.

Educational Background

Level	no.	(%)
Non-degree	4	(16)
Bachelor's degree	10	(40)
Master's degree	6	(24)
Ph.D. degree	5	(20)

Distribution

Region	Non-degree	B.S.	M.S.	Ph.D.	total	(%)
Southeast Asia/ Pacific	1	4	3	2	10	(40)
Asia/Middle East	0	1	1	3	5	(20)
Africa	3	0	2	0	5	(20)
Middle America	0	4	0	0	4	(16)
Europe	0	1	0	0	1	(4)
Total (%)	4 (16)	10 (40)	6 (24)	5 (20)		

Financial Support

Financial assistance and/or full scholarship support was provided through several institutions. The funding level can be divided into primary and secondary levels (Figure 2). The primary funding level entails one of three categories: (1) living allowance and fees ($8,000 U.S.), (2) fees only ($4,400 U.S.) and (3) living allowance only ($3,600 U.S.). Cost for the course went up slightly in 1988. Adjustments included $6,000 for tuition and fees plus $3,600 for living allowance. For the purpose of this survey, the majority of participants were familiar with the original cost. Secondary funding covered transportation costs to and from Colorado.

The main source of assistance at the primary level was TCCP. A total of nine trainees, 36 percent, were fully supported by the program. An additional eight had their fees either covered or waived. This combined total represents 68 percent of the respondents and signifies a strong financial commitment on the part of TCCP to assist trainees. The first year of training, Fall 1985 through Spring 1986, TCCP assisted 90 percent of the trainees in some capacity. This percentage dropped off sharply in the following years as alternative sources were identified and funding allotted for TCCP assistance decreased. To emphasize the importance of adequate financial support for training, a total of 24 would-be trainees applied to the Course from 1985 to present and were accepted, but due to lack of funding have not been able to attend.

The second primary donor was USAID with support for 24 percent of the respondents, half of which were fully supported. Those Missions contributing full support were the Fiji Islands, Morocco and Zimbabwe. An additional 16 percent of the respondents reported they had

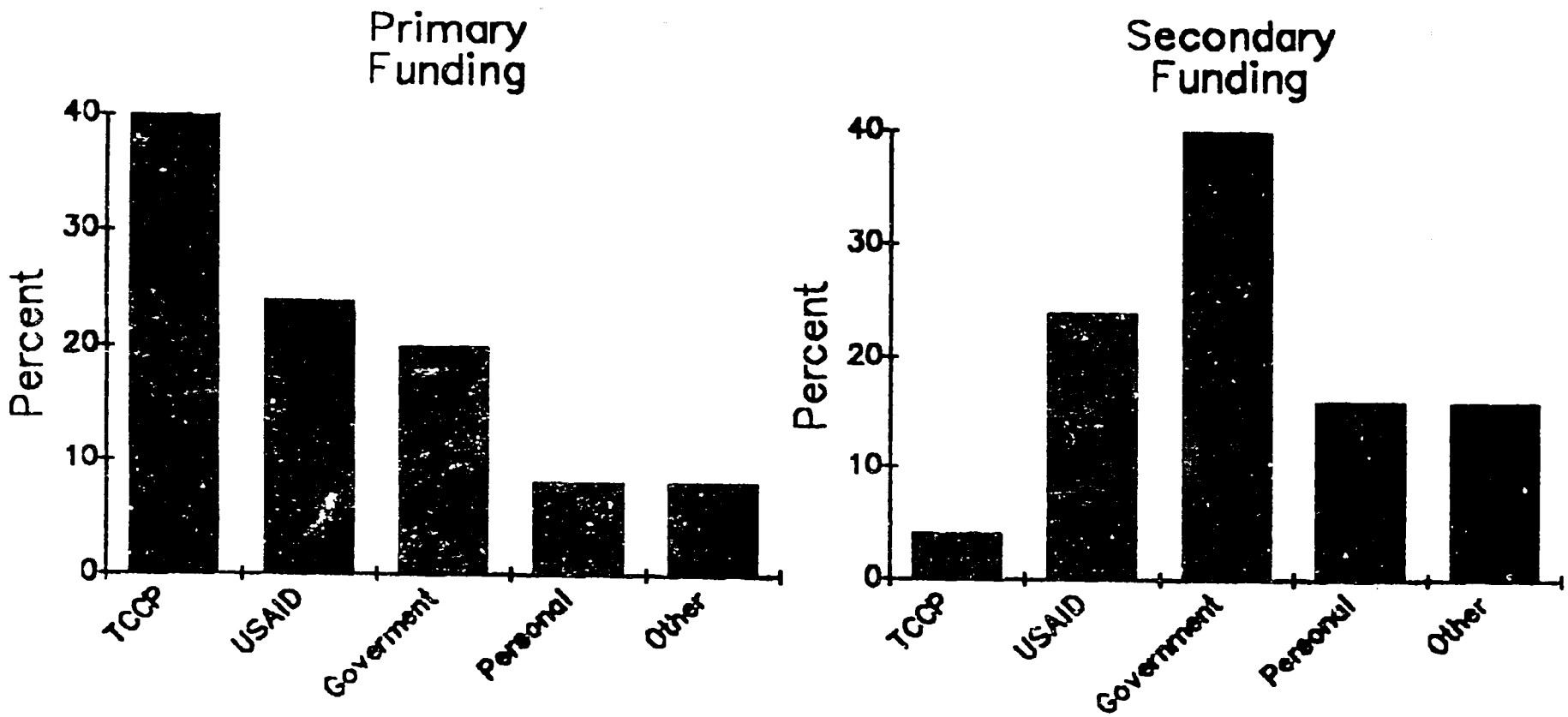

Figure 2. Sources of Financial Support

approached their home Missions but had been denied. The next source of primary assistance, at 20 percent, was home government institutions. Trainees from Saudi Arabia and Bulgaria were fully supported (8 percent) with the additional 12 percent included in combined Government and TCCP financial collaborations. An additional 28 percent of the respondents reported they approached their governments regarding financial support, but had also been denied. The final sources of primary funding, representing 8 percent each, are listed as "Personal" and "Other". The "Other" category signifies joint support from the Food and Agriculture Organization of the United Nations and the Institute for Atomic Energy and Agriculture (FAO/IAEA) which supported one trainee, and a private business sponsorship of another. The extent to which trainees received initial support from home institutions, whether USAID Missions or Government, played an important role in acquiring in-country support upon their return, and will be discussed later.

Secondary funding (transportation) displayed an interesting and varied distribution. The leading source of assistance was from home governments, with 40 percent of the total. USAID with 24 percent of total support was next. The "Personal" and "Other" categories, which included the World Bank, Fulbright Assistance, and the FAO, provided support for 16 percent of the respondents. TCCP assisted in 4 percent of the transportation funding via a development fund expenditure in conjunction with an existing collaborative agreement in the Philippines.

Pre-Training Career Information and Research Background

Training Background Information

Three areas were surveyed: career position, the amount of previous tissue culture experience, and the level of expertise regarding specific research techniques (Figure 3).

The majority of respondents, 48 percent, were research/technical assistants. The next highest categories were student and professor/lecturer at 16 percent each. Research coordinators were 8 percent, and a combination category applied to 12 percent of the respondents. This combination category included two trainees who were both students and research assistants, and one who was both a lecturer and a research assistant.

The relatively high number of trainees involved in some area of plant research prior to training explains the consequently high percentage (60 percent) of respondents who answered the category of "some tissue culture experience" on the questionnaire. Those who answered they had "already been using tissue culture a great deal" accounted for 12 percent in the considerable tissue culture experience category. A total of 28 percent of the respondents had no tissue culture experience prior to training.

The levels of tissue culture exposure and research expertise were grouped into two categories for purpose of analysis. The Basic techniques include knowledge of stock solution and media preparation, callus culture, suspension culture, somatic embryogenesis and vegetative propagation. The Advanced techniques are identified as anther culture, embryo rescue, protoplast isolation and culture, and virus indexing. A total of 40 percent of the respondents were familiar with the Basic techniques and 52 percent with the Advanced.

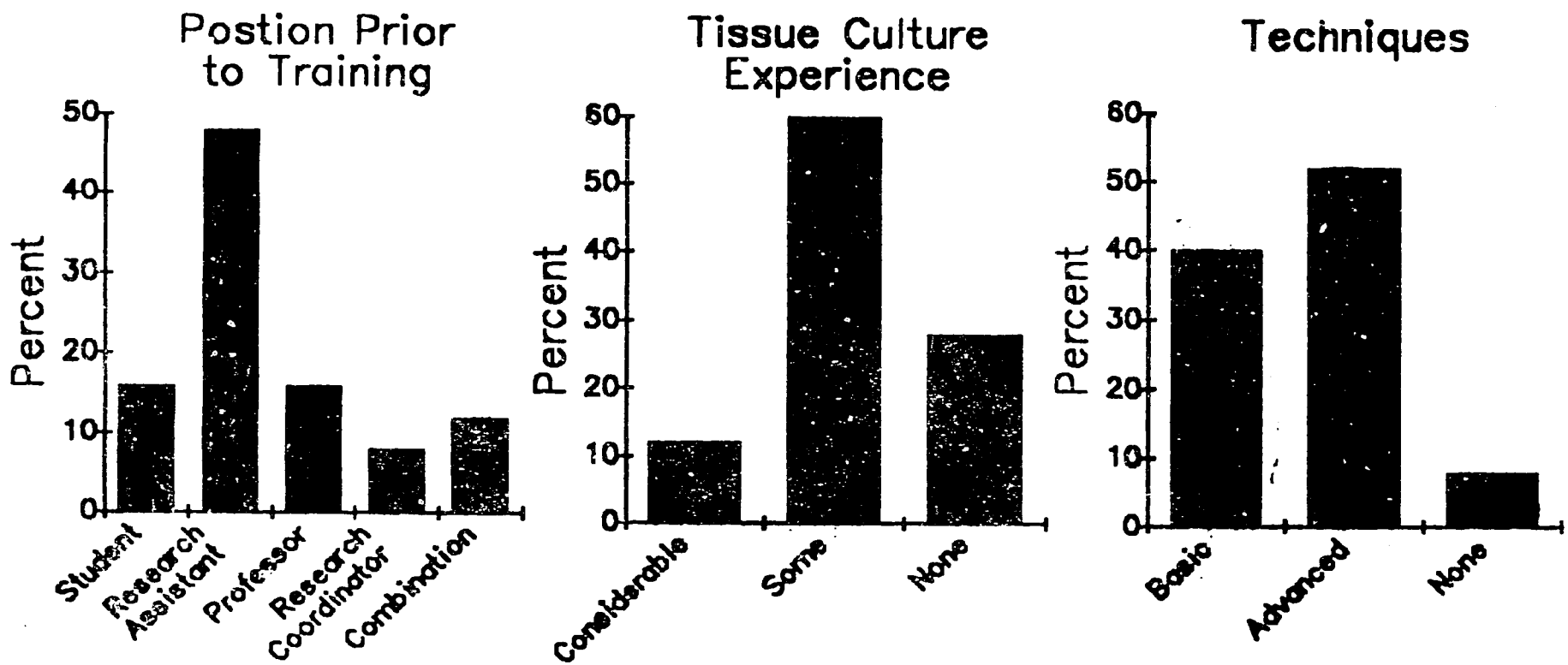

Figure 3. Training Background Information

The reason Advanced is relatively higher is due to several of the trainees having had exposure to virus indexing through previous course studies (primarily plant pathology at universities).

In the survey files 28 percent were recorded as having had no prior tissue culture experience. Yet, only 8 percent admitted having neither Basic nor Advanced technique background. This apparent discrepancy may be partially explained in this manner. On the mailed questionnaire 12 percent acknowledged previous knowledge of stock solution and media preparation both of which are considered as Basic Techniques. Another 8 percent reported having had experience in stock solution preparation and virus indexing, but were on record as having had no general tissue culture experience. This latter group were listed in this study as reporting previous experience in Advanced techniques. Since the follow-up questionnaire was specific, we can only assume that this specificity and a greater familiarity with the terms allowed the trainees to be more accurate in describing their previous experience.

TCCP course material will not be discussed in this report, due to ample coverage in TCCP publications and handbooks (Siriwardana, 1987; Siriwardana and Hildreth, 1987). An outline of course objectives and materials is listed in Appendix B. It is important to note that regardless of the initial level of expertise, 84 percent of the respondents were affiliated with plant research/crop production prior to training and 64 percent had tissue culture laboratories or research institutions to return to and continue their work. The extent to which training was implemented is discussed in the next section.

Post-Training Information and Course Evaluation

Training Application

Upon immediate return to their home countries, 60 percent of the respondents returned to the same institution and position they held prior to training (Figure 4). Twenty-four percent returned to the same place of employment but changed jobs, enabling them to use the training further. Only 4 percent reported returning to the same place of work, but changing jobs in a manner that prevented them from further tissue culture research. The category listed as Career Change represents 12 percent (three respondents) who did not return to work. Of these three, two stayed in the United States to pursue graduate or bachelor's degrees, and one got married.

Three years have passed since the first group finished training. When asked how their training is currently being implemented, 60 percent responded they are active in research, with nearly half of this group (28 percent) using basic as well as advanced techniques in their current work. Since finishing training, several respondents have enrolled in advanced degree programs. A total of 20 percent are currently pursuing various degrees either in the U.S. or in LDC's. Twelve percent of this group are still active in research, laboratory management and/or teaching while enrolled in a degree program. The total percentage of respondents who are not currently using their training (due to either unemployment or career changes) is 20 percent.

Job Responsibilities and Changes Due to Training

The respondents were asked if attending TCCP's training course had enabled them to advance their career through various socio-economic gains (Figure 5). These gains were listed in the questionnaire as:

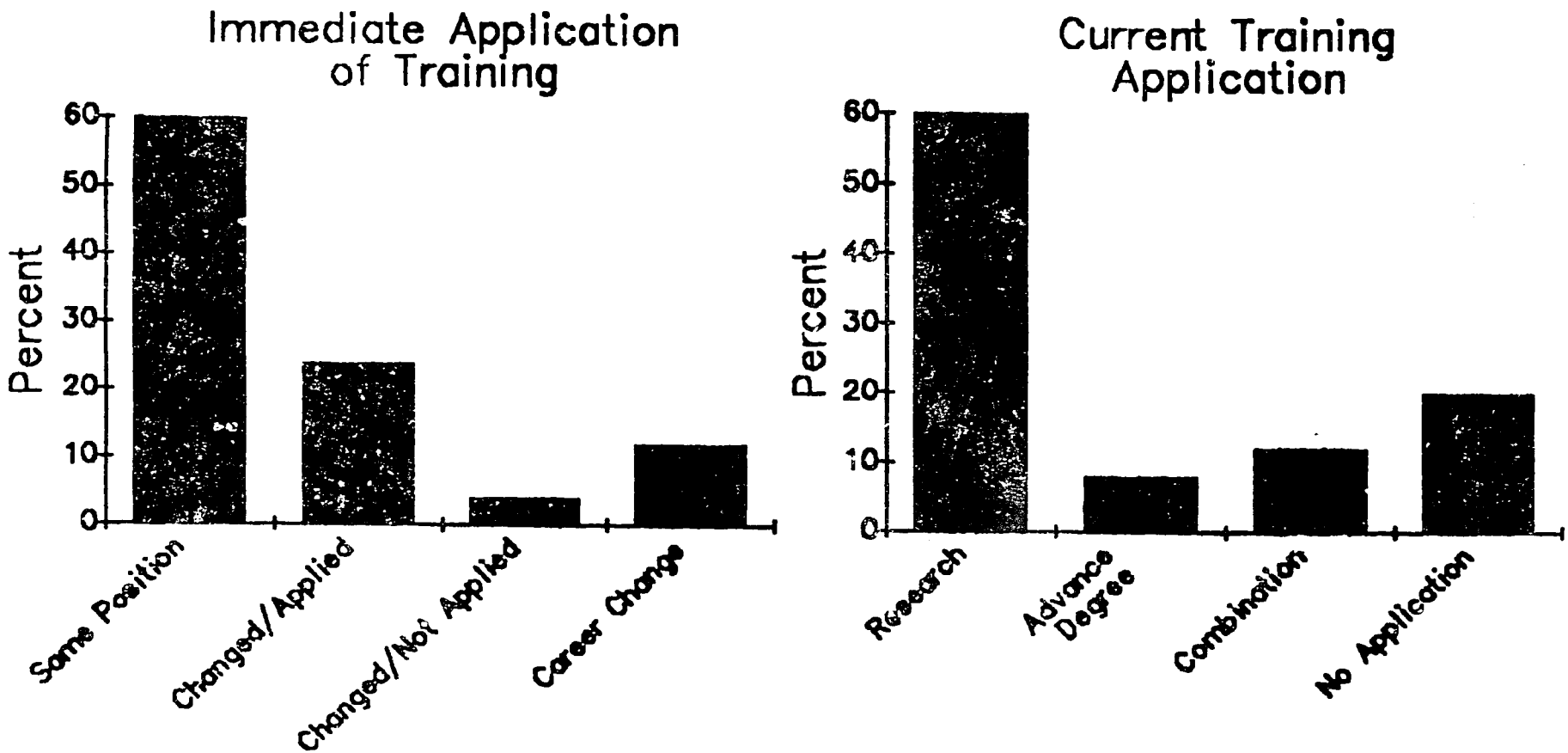

Figure 4. Training Application After Returning to Home Countries

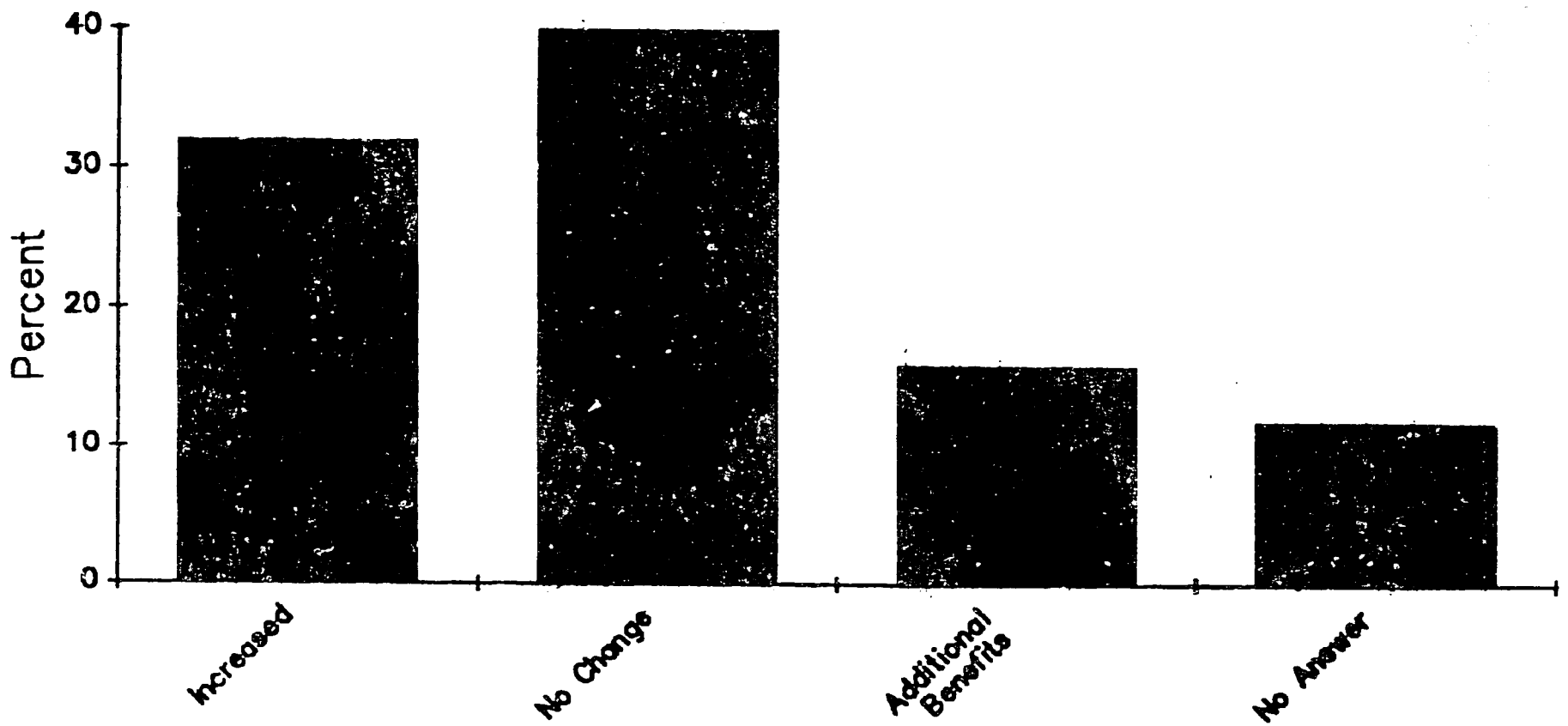

Figure 5. Job Responsibilities and Changes due to Training

increased responsibilities, advancement in rank, raise in pay, moving to a better geographic location, and increased benefits (i.e. housing, retirement plan). The majority of respondents (40 percent) replied the training had brought no significant changes while 32 percent reported increased job responsibilities. Twelve percent of those who answered increased job responsibilities also felt the training held no significant career changes. This was interpreted to mean no noticeable long-term changes as opposed to short-term (i.e. job responsibilities), or the changes that did occur may not have been what were anticipated. Sixteen percent of the respondents reported receiving a combination of the various benefits. The following example illustrates the benefit combinations. One trainee reported increased responsibilities with advancement in rank, as well as submitting a 10-year project proposal for coconut tissue culture to the Gesellschaft fur Technologische Züchtung (GTZ) which received approval for implementation beginning in 1989. Two other trainees reported increased responsibilities with advancement in rank and raise in pay. Finally, a fourth respondent described his benefits as including increased responsibilities with "increased exposure and confidence". Another respondent felt the training helped him to better understand the "potentials and limitations of tissue culture in crop improvement". Three respondents (12 percent) did not answer due to lack of current application of their training.

Additional Training Information

The continuation of both personal training/studies and training of others was also surveyed. When asked if they wished to pursue additional training, 48 percent of the respondents expressed a desire

to pursue a degree program (Figure 6). This distribution entails 8 percent at bachelor's level, 16 percent at Master's level, and 24 percent desiring Ph.D. studies. A non-degree program specializing in advanced training was preferred by 24 percent. A total of 16 percent would like to pursue both a degree and a non-degree program if given the choice. Although a combined total of 65 percent would be interested in advanced tissue culture training, no one identified existing courses in their countries. Only 8 percent are not interested in further studies of any type and 4 percent (one trainee) did not answer this question.

The trainees were also asked if they had been involved in training additional researchers/scientists in their countries since their return. Forty-four percent of the respondents answered positively. The combined number of people who have been trained is 43. The techniques which have been applied range from basic lab techniques to regeneration, callus induction, meristem culture, and virus elimination, as well as stress selection and screening for drought and salt tolerance. A variety of crop/plant material of regional importance have been used including horticulture crops, ornamentals, and cereal crops. Plans for a basic course have been implemented by one of the Philippino trainees to teach "stock solution, media preparation, and meristem culture to an enthusiastic group of businessmen engaged in plant culture, including technicians and research associates".

The need for combining regional efforts to produce future plant tissue culture courses and to avoid duplication of resources (both human and financial) is becoming more and more apparent in LDC's. Regional training which entails in-country cooperation as well as

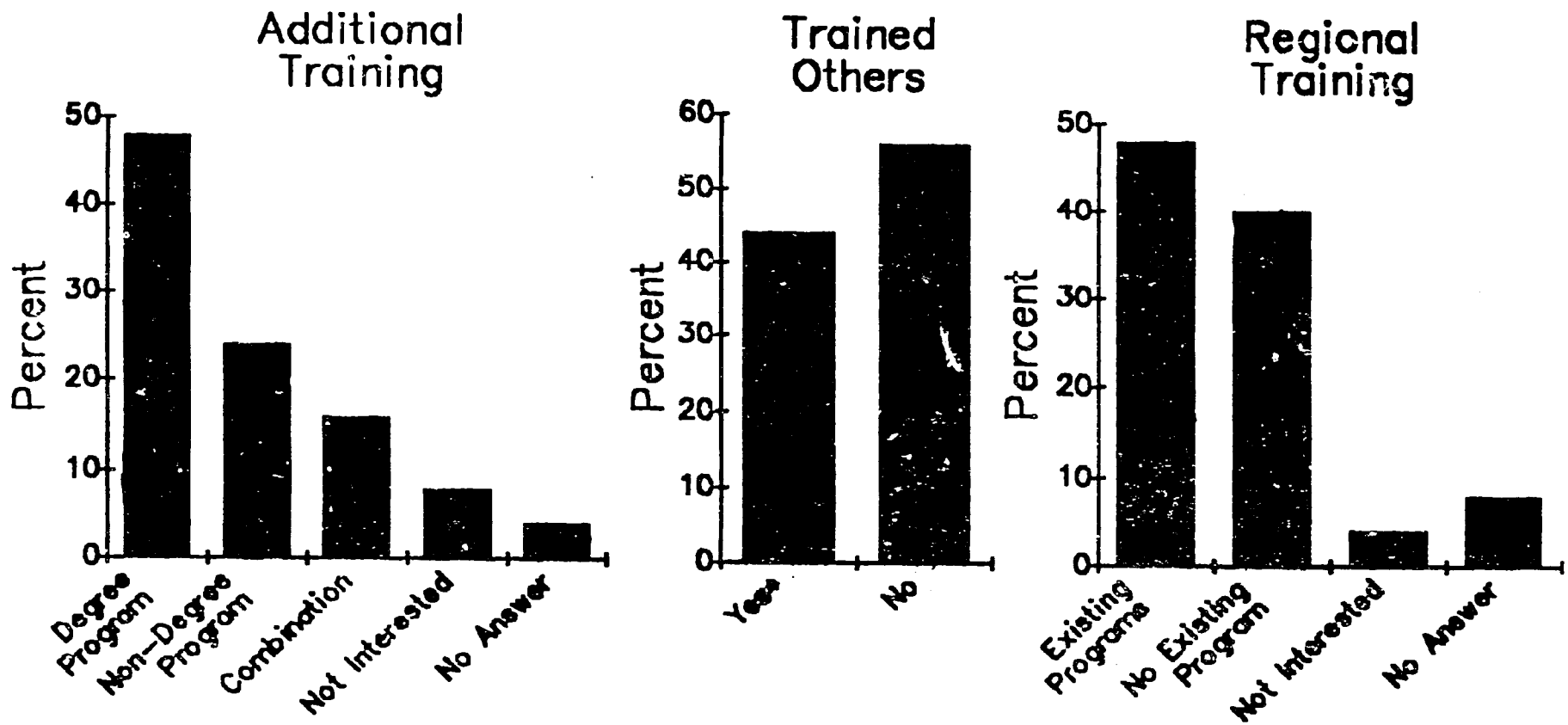

Figure 6. Additional Training Information

- 43 Additional People Trained

centralized programs for entire regions have become necessary in recent years. When surveyed as to whether they would like to be involved in organizing additional short-term training courses in their region, an overwhelming 88 percent of the respondents answered positively. Forty-eight percent of this group said they are also aware of existing programs in their countries. Those respondents who knew of short-course training in their regions identified national institutes, universities and several IARC's as the appropriate sources.

The concept of regional training is one which TCCP has given recent support. Due to difficulties in funding and language barriers, which prevented potential trainees from attending the six-month training course at CSU, various collaborations were formed with scientists in IPBNet to administer regional courses. The first course was established at El Centro Agronomico Tropical De Investigacion y Ensenanza (CATIE) under the direction of Dr. Victor Villalobos, which is taught in Spanish and runs an average of three months, twice a year. The course focuses on crops of regional importance (i.e. bananas, plantain, coffee, palm).

A second course under the direction of Dr. Mohamed Aaouine of the Institut Agronomique et Veterinaire Hassan II (IAV Hassan II) Complexe Horticole, in Agadir, Morocco, will take place in May-June of 1989 and will be taught in French. This course is a combined effort of five Moroccan instructors from three institutions; IAV Hassan II, Institut National de la Recherche Agronomique (INRA), and Mohamed V University (TCCP Annual Report, 1988). One of the instructors is a graduate of the TCCP course and a survey respondent, another a recent Ph.D. graduate from the CSU Department of Horticulture.

TCCP Course Evaluation

When asked if the TCCP training program met respondents expectations, 88 percent answered affirmatively (Figure 7). When asked if the program prepared the respondent for the problems/challenges encountered in their current research, 80 percent said "yes", 8 percent "no" and 12 percent responded "not applicable to current work". Those who were displeased mentioned a desire for increased knowledge of additional techniques on a greater variety of crops. Those who felt the course structure too general mentioned a desire for more specialized training, such as genetic engineering, and specific metabolite responses under stressed conditions. These statements usually corresponded with more advanced backgrounds on the part of the respondents and will be addressed in the next section.

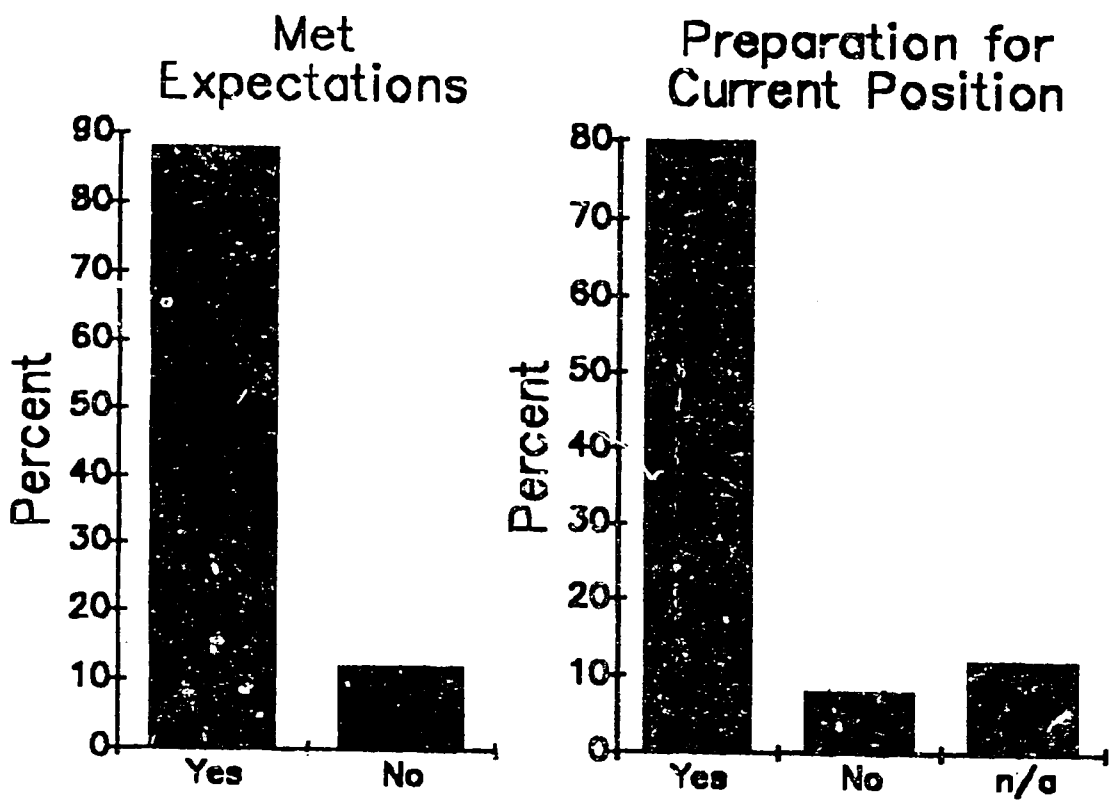

Figure 7. TCCP Course Evaluation

Evaluation of the TCCP Training Experience

The final section of the questionnaire asked for suggestions to improve the training program. The respondents were also asked to apply their suggestions to IPBNet and its role in program development.

The majority of respondents, as mentioned earlier, believed the course was well organized and provided them with the necessary knowledge. For the most part, the suggestions focused on the course structure and reflected the diverse needs and varied backgrounds of the respondents. For instance, 24 percent of the respondents suggested the course be divided into separate sections, beginner and advanced. The latter to be more research-oriented and a means to address more specific research needs. An equal percentage of respondents requested that advanced courses be offered as a second phase to their preliminary training. Those desiring two levels of courses were respondents who arrived at CSU with more advanced knowledge of tissue culture and felt the initial section dealt with techniques with which they were already familiar. Advanced studies in protoplast culture and fusion techniques were requested most. Other areas include *in vitro* selection for disease resistance, herbicide tolerance and various environmental stresses (in addition to NaCl and drought). A combined total of 20 percent of the respondents asked that more gene transfer, biochemical analysis and various aspects of molecular biology be included. Twelve percent of the respondents requested more time be spent on suspension culture, virus indexing and further greenhouse training.

Other recommendations dealt with the logistical rather than the technical orientation of the course. Some felt the lecture section should be shortened to allow individual research projects to begin

earlier in the six-month period. In addition to this suggestion others requested more time for group discussion and problem solving.

The reason for requesting both increased research time and group discussions was a feeling of not accomplishing goals or "finishing" research projects before the end of the Course. This is not an uncommon dilemma for it is experienced by scientists at all levels of research and is certainly not unique to a six-month basic course. Nevertheless, several respondents suggested the course be lengthened to an eight to twelve month period, particularly for "first-time tissue culture scientists." Since the trainees presented their results and project findings to the TCCP audience at the end of each training period, several respondents requested the opportunity to present additional seminars to further their professional experience. Other recommendations included increased field trips to additional laboratories, greenhouses and farms in Colorado. Inclusion of a field evaluation component was also suggested as a means of increased field testing knowledge.

Frustrations resulting from training in a laboratory fully stocked with modern equipment and supplies, then returning to laboratories of lesser means may be a problem for many scientists trained in developed countries. Several respondents verified this frustration by describing their problems since leaving TCCP. Some African respondents felt it very important that trainees have a required B.S. before attending the TCCP course. Without the degree, their "technical rank" precluded using home laboratories for additional training and research. This is supported in another study (Lee, 1981) where the needs for relevant training is emphasized and

considered a critical factor in later application. Other respondents felt the course should be more specifically directed towards techniques applicable to home country facilities. On the surface, this suggestion may appear to be contradictory to the expressed need for more advanced training reported earlier. It is not. It does, however, illustrate the diverse needs of trainees and the variety of programs necessary to meet these needs.

Another area of frustration is the inability to continue research due to lack of funding at home. To solve the funding problem, several other respondents requested more assistance in writing proposals to seek international funding with the assistance of TCCP. This request for TCCP assistance included the obtaining of small grants, receiving expert advice and listing future job opportunities. A total of 44 percent of the respondents requested increased assistance in either the area of preparing proposals and/or a more general request of increased availability and assistance from TCCP staff, specifically the Project Director and the Associate Director.

The need for Course follow-up included several requests and suggestions regarding IPBNet's extended role. Feelings of professional isolation and concomitant frustrations were voiced by 24 percent of the respondents. Some felt a need for exchanging research information and problem-solving techniques. One respondent suggested a special mini-network be set up specifically for former trainees. Several others requested assistance in obtaining chemicals and supplies for their research. Still others would like assistance in setting up workshops and financial assistance to attend IPBNet conferences. Several suggestions were made regarding a regionalization of IPBNet. The idea of "satellite" or "sub-stations"

was presented in detail from several respondents. These satellite stations would have regional coordinators who would be directed from the TCCP/USAID headquarters. Funding was identified as coming from USAID, specifically with increased cooperation from the USAID Missions.

Summary and Conclusions

The varied responses and information identified in this study outline the complexities of the challenges facing effective TCCP program assessment. The areas covered are not simply technical in nature. Nor does any one area stand out as an exclusive priority. It is rather a combination of approaches that will need to be pursued in order to effectively facilitate continued growth. The Course offered shared knowledge. This knowledge when used and further implemented is the indicator of the program's overall success. As mentioned in the Study of Training in the CGIAR System (1984):

> "The training experience increases knowledge and skills, enjoyment of intellectual and physical labour, motivation, determination, purpose and confidence. Continuing contact...afterwards offsets isolation and helps a participant to feel that he is a valued citizen of his professional world."

TCCP and USAID have a responsibility to see that the training is used and implemented in existing country programs. This is not easy, as the individual needs are incredibly diverse. Similar conclusions were drawn in an Amideast study of USAID participant training programs for Egyptians (Alkamel, 1984):

> "Greater attention needs to be paid to the diversity of trainees' abilities...the structure and content of the programs available need to be examined to determine whether their breadth can accommodate the full range of skills of the current generation."

The same must be done for TCCP's program. In order to judge what is feasible in the future, a separation and further definition of basic "needs" vs. "wants" is required. In the information gathered from survey respondents the following basic needs have been identified:

Tools: The Course structure should accommodate the return situation of the participants. Whether geared

towards a beginning or advanced level of expertise, proper laboratory facilities and applicable techniques should be established in the home country before training commences. This is especially true for those sponsored by their home governments or USAID Missions. Slight deviations are expected for those who come with personal funds to obtain knowledge for their own use.

Resources: Adequate means of obtaining chemicals, laboratory equipment and basic research facilities must be identified for training to be of use in home countries.

Knowledge: Continued linkages with researchers after training is required to facilitate a necessary flow of information. This include access to various scientific journals, and possibly membership in professional societies in developed countries.

These basic needs differ from "wants" as they are necessary for establishment of research, additional training, and eventually autonomous growth in the LDC's. Whether considered basic or secondary needs, they require financial assistance. This is a frequently encountered problem for scientists and institutions alike.

As international funding agencies become increasingly inundated with various requests, the responsibility lies with such networks as IPBNet to assist in avoiding duplication of programs and facilitate collaborative efforts. This can also be applied to training and

coordinating TCCP training efforts with those of the IARC's, FAO, UNDP, IAEA, ICRO and various U.S. university programs. The extent to which TCCP and IPBNet enter into a second phase of growth and development is also a question of financial support. The final recommendations in this study will be based on the assumption that funding continue and program adjustments are made accordingly.

Recommendations for Future TCCP Training Programs

1. Two course programs, basic and advanced, should be offered at TCCP to facilitate additional training for either former trainees or short-term specialized training. Additional experts will need to be hired on a consulting basis to provide topical assistance. These special sessions could be shorter in length (4-6 weeks), with a combination of two to three topics per training session. The basic course would remain six months in length and could incorporate additional greenhouse studies and extended field trips to farms and other laboratories in Colorado. Collaborative efforts with other CSU departments should also be pursued to incorporate participation from Horticulture, Agronomy, and Plant Pathology and Weed Science personnel more effectively.

2. If different sections and levels of expertise are taught, a more rigorous selection procedure will be necessary to more closely match trainees' expectations, knowledge and skills with the Course agenda.

3. Continued development of regional training programs is recommended. Eventually all basic training may be accomplished through regional programs, with specific technique instruction taking place in developed country laboratories or various IARC facilities. These courses would vary in length, but should be taught in the appropriate regional language using crops and plant material suitable to the region. In addition to the course established at CATIE (Costa Rica) and IAV Hassan II (Morocco), strong potential programs could be established in the Philippines, Thailand, Egypt and either Kenya or Zimbabwe.

4. TCCP/IPBNet courses should work toward integrating with existing national programs in the LDC's and efforts on the part of the IARC's and other developed country institutions. The problem of course duplication can be alleviated through extended cooperative efforts, freeing up needed resources.

5. Greater assistance and cooperation from USAID Missions is needed to assist in regional programs and specialized training. TCCP and Mission linkages could be strengthened by developing course follow-up programs to be performed on an individual basis with the assistance of Mission personnel and contracted specialists in collaboration with IPBNet. The correlation found between Mission support and the scientists successful integration in home country programs provides a strong point for long-term biotechnology planning and development. These efforts will require the support of the Project Monitor in the Science and Technology Bureau in Washington, D.C. to be properly implemented.

6. IPBNet would become regionalized to more effectively coordinate the expanded program. This could be modeled after several of the university consortiums in the U.S. such as the Mid America International Agriculture Consortium (MIAC) or the Consortium for International Development National Agricultural Research Project (CID/NARP) program in Egypt. Staff members would be stationed in various LDC's to implement programs and remain in contact with national programs. IPBNet could then function as a connecting link and placement center for training programs with collaborators both in the U.S. universities and LDC institutions.

7. Follow-up and training program coordination would continue to take place from TCCP headquarters to better meet IPBNet member needs. Newsletter articles could include a section dedicated to Training Follow-up to provide accounts of alumni research and accomplishments. The idea of assisting trainees in communication with other scientists and continued programs is crucial. Assistance from USAID and other sources could be pursued to sponsor professional membership in scientific societies in developed countries for scientists unable to sponsor themselves.

8. Further comprehensive evaluations are needed on a periodic basis to further incorporate alumni recommendations and monitor extended Course follow-up.

Literature Cited

Alkamel, F. M. 1984. Highlights and some interpretations of the report: characteristics and utility of USAID participant training programs for Egyptians. Amideast. AID-sponsored study.

Buttel, F.H., B. Kenny and J. Kloppenburg, Jr. 1985. The IARCs and the development and application of biotechnologies in developing countries. In: Biotechnology in International Agricultural Rice Research Institute. IRRI. pp. 383-393.

Cohen, J.I., D.L. Plucknett, N.J.H. Smith, K.A. Jones. 1988. Models for integrating biotech into crop improvement programs. Bio/Technology 6:387-392.

Dembo, D., C. Dias, W. Morehouse. 1987. Biotechnology and the third world: caveat emptor. In: Development: Seeds of Change. 1987:4 pp. 11-18.

Elmer, L. and T. Moser. 1986a. Annotated bibliography of participant training evaluations, studies, and related reports. AID Occasional Paper No. 8. U.S. Agency for International Development, Washington, D.C.

Elmer, L. and T. Moser. 1986b. An analysis of AID participant training projects. AID Evaluation Occasional Paper No. 12. U.S. Agency for International Development, Washington, D.C.

FAO. 1980. Agricultural training report of an evaluation study. Food and Agriculture Organization of the United Nations, Rome.

Kenney, M. 1987. The university in the information age: biotechnology and the less developed countries. Development: Seeds of Change 1987:4 pp. 60-67.

Lee, M.Y., M. Abd-ella, L.A. Burks. 1981. Needs of foreign students from developing nations at U.S. colleges and universities, Chapter 6. S.C. Dunnett (Ed.) by the National Association for Foreign Student Affairs through a contract with the U.S. Agency for International Development, Washington, D.C.

Moser, T. and L. Elmer. 1986. Review of participant training evaluation studies. AID Evaluation Occasional Paper No. 11. U.S. Agency for International Development, Washington, D.C.

Plucknett, D.L., N.J.H. Smith, J.T. Williams and N.M. Anisshetty. 1987. Gene Banks and the World's Food, Chapter 5. Princeton University Press.

Ruivenkamp, G. 1987. Social impacts of biotechnology on agriculture and food processing. Development: Seeds of Change 4.

Sigburbjörnsson, B. 1985. The international program of the Joint FAO/IAEA Division with special reference to biotechnolgy. In: Biotechnology in International Agricultural Rice Research Institute. IRRI. pp. 371-382.

Siriwardana, S. 1987. Plant tissue culture methods. A laboratory manual. Tissue Culture for Crops Project, Colorado State University, Fort Collins, CO.

Siriwardana, S. and G. Hildreth. 1987. A handbook for tissue culture laboratory management practices. Tissue Culture for Crops Project, Colorado State University, Fort Collins, CO.

Smuckler, R.H., R.J. Berg, and D.F. Gordon. 1988. New challenges, new opportunities. U.S. cooperation for international growth and development in the 1990's. Michigan State University Center for Advanced Study of International Development.

TAC Secretariat. 1986. Report of the study of training in the CGIAR system. Consultative Group on International Agricultural Research. TAC Secretariat. Food and Agriculture Organization of the United Nations, Rome.

Thorpe, T. 1981. Report: international training course plant tissue culture methods and applications in agriculture. University of the Philippines at Los Banos, Philippines. October 25-November 7, 1981. UNESCO, ICRO, Panel on Plant Cell Biology.

Tissue Culture for Crops Project. 1988. Annual Report. Colorado State University, Fort Collins, CO.

Tissue Culture for Crops Project Cooperative Agreement. 1984. USAID Cooperative Agreement #DAN-4137-A-00-4053-00.

USAID Handbook No. 10. 1981. U.S. Agency for International Development, Washington, D.C. April. pp. 30-31.

USDA Technical Short Courses Annual Report. 1987. U.S. Department of Agriculture, Beltsville, MD.

West, R.C. and J.P. Augelli. 1976. Preface. Middle America Its Lands and Peoples. Prentice Hall, Inc., 2nd ed. Englewoods Cliffs, NJ.

Zeisel, H. 1966. Say it with Figures, Chapter One. Harper and Row Publishers, 5th ed., revised, New York, NY.

Additional Resources Contacted

Dr. Roger N. Beachy
Washington University, St. Louis, USA

Dr. Karen W. Hughes
University of Tennessee, USA

Dr. Kutty K. Kartha
PBI/NRC, Canada

Dr. A. Mujeeb-Kazi
CIMMYT, Mexico

Mr. Jean-Marc Meyour
FAO, Rome, Italy

Dr. Toshio Murashige
University of California, Riverside, USA

Dr. Frantisek J. Novak
Joint FAO/IAEA Program, Austria

Dr. Gregory C. Phillips
New Mexico State University, USA

Dr. Donald L. Plucknett
CGIAR Secretariat, USA

Dr. William C. Roca
CIAT, Colombia

Dr. K. N. Satyapal
UNDP, New York, USA

Dr. Trevor A. Thorpe
University of Calgary, Canada

Dr. Indra K. Vasil
University of Florida, USA

Dr. Victor M. Villalobos
CATIE, Costa Rica

Appendix A

Post-Training Questionnaire
for the
Tissue Culture for Crops Project (TCCP)
Colorado State University, U.S.A.

Personal Biodata:

Dr.
Miss
Mrs.
Mr.

_____
Last name First name Middle initial

Current occupation: _____

Institution: _____

Pre Training Course Information [please place an "x" before appropriate answer(s)]

1) Before attending TCCP's training course I:

____ was a student
____ was a research/technical assistant
area of research: _____
____ was a professor or lecturer at: _____
(please list school/university and topic of instruction)
____ was a research coordinator, in charge of a research lab/facility
area of research: _____
____ other (please explain) _____

2) Before coming to TCCP I had:

____ no tissue culture experience
____ some tissue culture experience
____ already been using tissue culture a great deal

3) Before attending TCCP's course I was familiar with the following techniques: (check as many topics as apply)

____ stock solution and media preparation
____ callus culture
____ suspension culture
____ meristem culture
____ anther culture
____ embryo culture
____ somatic embryogenesis
____ morphogenesis
____ protoplast isolation and culture
____ virus indexing

Which, if any, of the above techniques were used in your work/research before attending TCCP? (please list):

4) I attended TCCP through the following scholarship or financial assistance:

____ TCCP full scholarship
____ TCCP partial scholarship
(circle appropriate answer)
a. Living allowance and fees ($8,000) USD
b. Fees only ($4,400) USD
c. Living allowance only ($3,600) USD
____ Personal Funding
____ Other source of funding
Name of Sponsor:
Type of Scholarship:
(airfare, living allowance, fees, etc.)

5) Before coming to TCCP, I approached the following agencies or institutions for financial support:

____ Winrock International
____ World Bank
____ FAO
____ USAID Mission in your country
____ Rockefeller Foundation
____ Ford Foundation
____ Government Agency (please list): _____
____ other (please list): _____
_____

Post-Training Course Information: [please place an "x" before appropriate answer(s)] Use blank page at end to complete answer if space is not adequate.

1) Upon returning to my country I:

____ Went back to work at the same place I was before going to Colorado
____ Changed institutions.
If so, are you at the same place now? ____ yes ____ no
How many times have you changed locations: 1, 2, 3.

2) Upon returning to work, I:

____ remained in the same position as I held before coming to TCCP.
____ changed positions. If so, did the change enable you to practice your training skills? ____ yes ____ no Please explain:
_____
_____

3) What aspects of your current job are directly related to the training you received at TCCP? _____
_____
_____
_____
_____

4) Did attending TCCP's training course enable you to advance your career objectives in any of the following ways?

____ increased responsibilities
____ advancement in rank
____ raise in pay
____ moved to better geographic location
____ increased benefits (housing, retirement plan, etc.)
____ no immediate significant effects in my career
____ other (please specify) _____

5) Do you wish to pursue additional training? ____ yes ____ no
If yes, which of the following:
____ Bachelor of Science
____ Masters of Science
____ PhD
____ Advanced or specialized tissue culture or new technology courses. (If you marked this category, are you aware of additional courses being offered in your country? Please list.)

6) Have you been involved in training additional researchers/scientists in your country?
____ yes
____ no
If yes, how many? _____
Which techniques and with which crops? _____

7) Which institutions in your country offer courses in short-term training in tissue culture or plant genetic improvement? _____

8) Would you like to be a part of organizing additional training courses in your area/region?
____ yes
____ no

9) Did the TCCP training program meet your expectations?
____ yes
____ no; if no - why? _____

10) Did the program address the problems/challenges you face in your research today?
____ yes
____ no; if no - why? _____

Please turn page for final question.

11) What do you suggest we change to better prepare or assist scientists like yourselves in future courses? (please address scientific as well as IPBNet issues)

Appendix B

Course Content

A basic course designed to teach the tissue culture research methodology, laboratory techniques, lab set-up and management.

Formal instruction in the first eight weeks. Supervised research for the rest of the session.

Two handbooks for use:

1. Plant Tissue Culture Methods. A laboratory manual. Compiled by S. Siriwardana, TCCP

2. A Handbook for Tissue Culture Laboratory Management Practices. Compiled by S. Siriwardana and G. Hildreth, TCCP

Course Objectives

This program facilitates dissemination of information to individuals and institutions intending to or actively employing tissue culture technology for research or teaching purposes.

Criteria for Selection of Candidates

Previous tissue culture experience

Geographic distribution of applicants

Establishment in home institution

Financial support available

Crop of interest

A. Lectures and Laboratory Exercises

Stock solution preparation
Sterile technique
Cell culture
Embryo culture
Morphogenesis
In vitro fertilization in crops
In vitro selection for stress tolerance
Media preparation
Callus culture
Meristem culture
Anther culture
Somatic embryogenesis
Virus indexing

B. Special Topics

Molecular biology
Use of statistics in tissue culture
Germplasm preservation
Set-up and management of a tissue culture lab
Greenhouse practices for tissue culture regenerants

C. Research

Trainees choose their crop - generally a food crop or a crop of economic importance to their country.

Trainee projects can also be on TCCP crops.

Components of projects:
- Research proposals
- Implementation
- Research seminar

Appendix C

Special thanks to the following people who helped make this study possible.

TCCP Course Graduates

Mr. Renato A. Avenido
Philippines

Mr. Raed F. Bakheet
Saudi Arabia

Ms. Ouafae Benlhabib
Morocco

Ms. Rosemarie Bressani
Guaatemala

Ms. Gabriela Casas-Carrillo
Mexico

Mrs. Olivia P. Damasco
Philippines

Ms. Merlina N. Dionzon
Philippines

Dr. Bishamber D. Gothwal
India

Mr. Todor K. Goubatov
Bulgaria

Ms. Iteu M. Hidayat
Indonesia

Dr. Flordeliza B. Javier
Philippines

Mr. Rachmat Kartapradja
Indonesia

Mr. Francisco Lopez-Guitierrez
Mexico

Dr. Marziah Mahmood
Malaysia

Mr. Andrew E. Matibiri
Zimbabwe

Mr. Ben A. Musyimi
Kenya

Mr. Simon M. Ndirangu
Kenya

Mr. Stanley N. Nganga
Kenya

Dr. Madhumati Purohit
India

Ms. Mussarat J. Raza
Pakistan

Ms. Erlinda P. Rillo
Philippines

Ms. Carol M. Rohrman
Guatemala

Mr. Takaniko K. Ruabete
Fiji Islands

Mrs. Benchamas Silayoi
Thailand

Dr. Indira Singh
India/USA