FORMATION OF HUMAN RESOURCES FOR AGRICULTURAL RESEARCH IN LATIN AMERICA, AND PARTICIPATION IN RESEARCH NETWORKS: The Case of Former CIAT Trainees.

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ABSTRACT

FORMATION OF HUMAN RESOURCES FOR AGRICULTURAL RESEARCH
IN LATIN AMERICA, AND PARTICIPATION IN RESEARCH NETWORKS:
Training researchers at CIAT

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This is a study of two aspects of the performance of persons who received training in research at the International Center of Tropical Agriculture (CIAT), Cali, Colombia, during the period 1969-79. The study focuses on two questions: 1) To what extent is the Latin American region building inventories of intermediate level agricultural researchers as a result of CIAT's training?, and 2) To what extent are former CIAT trainees participating in third cultural networks of science and technology?

The study population is predominantly composed of young applied researchers who occupy full-time professional positions at the middle levels of large, complex agricultural research and development institutes in Latin America.

The main findings on inventories of researchers are: a) this has been an effective process which exhibits some inefficiencies with respect to the ability of the region to retain trained persons in the sponsoring organizations and in the activity of research;

b) inefficiencies relate to a growing migration process; and c) efficiency in retention of trained persons is low during the first years of CIAT's training, but since 1975 tends to increase.

Additional findings indicate that research networks are highly promising for institutionalizing science and technology for agriculture in Latin America: a) about two thirds of the persons in the sample participate in networks of researchers; b) most linkages are at the loci of organizations and country, but almost one third of the significant connections are beyond these national boundaries; and c) the networks generated by the interaction among these researchers are highly structured: about one half of the participants are organized in twenty-two research groups ("invisible colleges"); most of these groups are specialized by fields of research; over three fourths of the groups are interorganizational, and one half of them are transnational. About one third of former CIAT trainees appear to be in a state of scientific isolation.

To Amparo,

Jairo Alonso,

Juan Carlos, and

David Alejandro.

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I would like to express my gratitude to all Latin American agricultural researchers who filled out the network questionnaires, as well as to those whom I had the opportunity to personnally interview. I hope that this piece of research may in some way be useful to the development of agricultural research in the region and to their personal professional development.

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CHAPTER I

INTRODUCTION

A. Focus of the study.

This is a study of training for agricultural research. The availability of effective researchers is a pressing difficulty faced today by people and organizations involved in the evolution of the indigenous science and Western science partnership in developing countries. During the last two decades scholars in the development literature have been emphasizing the need for less developed countries to increase the quantity and quality of their national scientific human resources (for example see Price, 1963; Moravcsik, 1975; Street, 1979; United Nations, 1979). It is argued that scientific capability is one of the factors which will enable less developed countries to be more self-reliant in solving their internal problems, to decrease their technological dependence on countries scientifically more advanced, and to more effectively participate in an increasingly interdependent world community.

The interest in focusing this study on one type of educational system development, research training in specific fields of agriculture, grew out of the hope of many people and organizations for the potential contribution of science-based technology in increasing

agricultural productivity. Such potential is regarded by both people from more developed countries (MDC's) and less developed countries (LDC's) as instrumental for the broader aim of supplying food for a growing global population.

One of the lessons learned by people engaged in international agricultural work during the past two decades is that, particularly for the Tropics, the generation of the biological components of production technology must be tailored to the local conditions in which farming is going to take place (Jennings, 1976). Such a requisite implicitly carries the need of having available task forces of skilled researchers at national and regional levels, who effectively work in the generation, validation, and adaptation of agricultural technology. This requires the development of appropriate educational systems. The number of researchers required for such a task is not always available in LDC's, and when available they do not always have the adequate skills (Byrnes, 1974; Wortman and Cummings, 1978; IADS, 1979a; IADS, 1979b).

One action designed and implemented to prepare scientific personnel for national organizations is non-degree training held in LDC's at international agricultural research centers (IARC's). The purpose of this study is to follow-up on post-training experiences of professionals from the Latin American and Caribbean countries who participated in training programs at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, during the period 1969-1979.

The study selectively examines two segments of former CIAT trainees' performance as researchers: 1) reincorporation of former

trainees into their organizations and stay in the activity of research, and 2) their participation in person-to-person networks for research interchange.

B. Independent variables.

Relationships between the above-mentioned aspects of former trainees' research performance and three selected factors are explored: 1) training content, 2) length of training, and 3) facilities available at home organizations for doing research in the fields in which people carry out their training. Other features of the training experiences are assumed to be similar for all participants: the philosophy and goals of the training program; its physical and organizational setting; the training facilities available at CIAT; and the quality of instruction, e.g., quality of instructors, delivering methods, and training materials.

1. Training content is assumed to reflect a substantive variable of the structure of science: the knowledge and technology basis available for doing research in different fields of science. Variation due to training content is explored by grouping the population in research-related commodities. Content is assumed to be similar within each research commodity, but different between them. The research and training work at CIAT is organized in four commodities: a) rice, b) beans, c) tropical pastures, and d) cassava. Therefore, these four categories of training content are separated in this study.

2. Length of training is defined as the time from physical arrival at CIAT to departure from CIAT, measured in number of months.

It is grouped in three levels: a) short training, when training took up to two months; b) intermediate training, when it took more than two months up to six months; and c) long training, for programs longer than six months.

3. Support facilities to do research. The degree of facility support needed for carrying out research once trainees go back to their home organizations is a structural variable which reflects the national priorities assigned to research within the countries as well as internal constraints within organizations. To account for this variable, the Latin American* countries which have sent professionals for training to CIAT were classified in eight groupings, two per commodity: those with more research facilities in each commodity, and those with less facilities. (See pp. 78-81).

C. Research questions and rationale.

The study is centered on the exploration of the two following questions: 1) To what extent is the region building inventories of human resources for agricultural research as a result of CIAT's training?, and 2) to what extent are former CIAT trainees participating in third cultural networks of science and technology?

1. Inventories of researchers. In the context of this thesis this expression means the number of persons available each year, who have appropriate training to carry out specific research tasks. The

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*The term Latin America is applied loosely in this thesis to mean the Western Hemisphere with the exclusion of the U.S.A. and Canada. The term Latin America is used interchangeably with thw words "the region".

building of effective research organizations has been postulated as one of the foundations of the institutionalization of science for agricultural development (Moseman, 1970). At the core of the building of agricultural research organizations is the problem of staffing (Drillon, 1977; Wortman and Cummings, 1978). The aim of building "critical masses" of trained researchers for staffing agricultural organizations in Latin America is difficult to achieve because of a high mobility of researchers out of the organizations which sponsor their training, and out of the activity of research.

If the goal of training programs at IARC's is to strengthen the research capabilities of national research organizations by helping them to train their research staff, immediate concerns with respect to training outcomes are: What has been CIAT's contribution in this respect? How effective and efficient has the region been in building human resource inventories for agricultural research with basis in CIAT's training? How is migration of researchers toward non-research activities affecting those inventories? For how long have professionals stayed in their sponsoring organizations after training? A crucial feature of scientific work is that the experience required for effective performance is developed by researchers through long periods of involvement with particular problems. Consequently, a question relevant to the issue of human research inventories is: How efficient has the region been in forming and retaining research experience in relationship to the personnel trained at CIAT?

There is no simple way to answer the above-stated questions. The formation of human research inventories may be appraised from the perspectives of different persons and interests. Four views are

envisioned and examined in this thesis: a) the perspective of the national organization, public or private, which sends members of its staff to advance their training with the expectation that they will return to the organization and utilize that training for better performing their duties; b) the perspective of the coordinator of a commodity program at the training organization, who expects to increase the number and quality of researchers working in a given subject, thus establishing a basis for future research collaboration; c) the perspective of the directors of the training organization, who expect that former trainees will engage in research work related to the center's mission and priorities; and d) the perspective of country-based and international research sponsors and science policy makers, who expect that trained personnel will engage in research-related work in the region. From this final perspective, it does not matter that professionals work for a particular organization or in a specific field; what matters is that they apply their training and contribute to the advancement of science and technology.

2. Participation in research networks. Interfaced with the building of formal research organizations, it is assumed that there is another substantive factor involved in the institutionalization of science in developing countries: the building of formal and informal channels for the interchange of research findings and resources, e.g., scientific literature and germ plasm. This study does not focus on the larger formalized channels, which are a part of organizations and programs, and which set the stage and form the base for all interpersonal relationships, but is limited to the person-to-person informal networks among working scholars.

In recent years, an increasing awareness and interest in the informal communication system of science has developed. The relevance of this system has been supported by findings in the sociology of science, which consistently assigns a central role to the personalized interchanges in the advance of research areas.

Such communication occurs among the most effective members of any field of research. These networks include interpersonal ties between researchers within a country and across national boundaries. The relationships between people from different societies create opportunities for "third cultural networks" to emerge; the cognitive nature of interchanges among researchers allow reference to those sets of people and relationships as third cultural networks of science (Useem, Donoghue, and Useem, 1963; Useem, 1967, 1971; Restivo and Vanderpool, 1974).

This study explores the extent to which former CIAT trainees are participating in third cultural networks of science and technology. Three aspects of networks are studied: a) the extent of their participation in research networks; b) the third cultural character of the networks in which former CIAT trainees participate; and c) the social structures of those networks.

D. Limitations of the study.

This descriptive study aims at developing a data-based analysis of the impact of training at an IARC upon two selected aspects of the research performance of agricultural researchers who took part in that form of training. The study does not pretend to test hypotheses or determine causal relationships. This follows

methodological limitations in design and measurement of post-training research performance in the particular population being studied in this thesis, and also practical limitations of time and financial resources.

1. Limitations on design. A comparative study of research performance of trainees and non-trainees would have been desirable. It would have required an experimental or at least quasi-experimental design. Experimental and quasi-experimental designs were found unfeasible for this study. Limitations were: a) independent variables of interest could not be manipulated in order to have random assignment of treatments to experimental groups; b) control groups were found unfeasible for at least two reasons: first, inventories of human resources in agricultural research were not found for most Latin American countries; and second, the identification of cohorts (an alternative to sampling from the population of Latin American agricultural researchers) is costly and there were concerns regarding equivalence of cohorts; and c) pre-test measures of research performance are not available for the population of former CIAT trainees, nor for candidates which were not admitted to the training program.

2. Limitations on measurement. Measurement of research performance in this particular population was another source of limitation for the study. Difficulties were found in applying three types of measures to the population under study: a) citations in the scientific literature; b) number of research papers; and c) number of professional and work associated activities. Citations are not available for most members of this population. Former CIAT trainees

usually publish their work in reports of their organizations where the identity of authors very often is not established. The same limitation applies to the second measure, research papers; in addition, this measure presents problems of equivalence. The number of professional and work-related activities carried out by agricultural researchers after training is a feasible measure for this population, but the problem of equivalence remains, and is even more critical because these professionals practice a wide diversity of research activities, depending on their speciality.

3. Practical limitations. A source of practical limitation was the circumstance that the study population is scattered across 26 countries and 182 organizations covering a wide geographical area from Mexico to Argentina. Time and financial limitations were related to the fact that the author was conducting this study under the relatively fixed boundaries of an appointment as a graduate student. Such constraints made the exclusion from this thesis of the reports of case studies carried out in Mexico and Ecuador necessary. Data collected for these case studies refer to a deeper examination of aspects of the research performance of former CIAT trainees in the sites in which they are presently carrying out their professional duties. Both personal interviews and ethnographic data about the work setting were gathered for this purpose. The author hopes to find opportunities to analyze and report those case studies after completing his graduate studies.

CHAPTER II

LITERATURE REVIEW AND THE STUDY CONTEXT

This chapter presents a review of pertinent literature in relation to the development of human resources and networks of researchers in the context of the institutionalization of science and technology for agriculture in Latin America.

The purpose is to provide a framework of concepts, facts, and interpretations--drawing upon a diversity of intellectual traditions--which are relevant to this thesis.

In as much as possible, literature selected for this chapter refers directly to developments that occurred in the region. However, ideas and lessons from studies focused on other regions of the world--more and less developed regions--are also included. This is the case of the sociological construct about third cultures of science, generated by John and Ruth Useem and several of their students (1963, 1967, 1971); the main empirical referents for these studies being four countries of South East Asia. General writings about S&T and about research networks are another example of material utilized for structuring this chapter, even though their authors in most cases did not focus specifically on Latin America.

These materials are arranged in six sections. The first two deal with general concepts about S&T, and about its spread in Latin America. The third section refers to concepts of institution building

and efforts at institutionalizing agricultural research in the region. The fourth part focuses on training opportunities and assessments of them, for developing human S&T capabilities for Latin American agriculture. The next section is a framework for examining the social structures and third cultures which develop among professionals who participate in research networks. Finally, the last section presents overviews on the empirical setting for this study: CIAT as a research and training organization; the food problem in Latin America; four crops as contextual setting; and the trainees' home organizations.

A. Rise of Western science and technology (S&T).

1. Western science: from magic to scientific knowledge.

Western science is a social phenomenon which evolved through a long period out of ancient cultures in the East, and crystallized in several countries of Western Europe about five hundred years ago. It was derived both from the ordered speculation of the magician priest, or philosopher, and from the practical operation and traditional lore of the craftsman. This phenomenon was backed in the Hellenic period, continued through the Roman and Middle Ages, incorporated Arabic contributions, and absorbed the intellectual advances ot the Renaissance (Bernal, 1939, pp. 13-34; Sagasti, 1979). Basalla (1967) mentions seven Western European nations as providing the original home for science during the 16th and 17th centuries: Italy, France, England, the Netherlands, Germany, Austria, and the Scandinavian countries.

The words "Western science" appear in the literature designating at least four different manifestations of this phenomenon: a) a product, e.g., scientific knowledge; b) a set of systematic

procedures, e.g., scientific method; c) a type of human work, e.g., scientific research; and d) a social institution, e.g., the collectively supported, specialized enterprise of scientific knowledge production.

A common definition of research is that of careful reseach or close searching. In Western science such search has been classified according to its purposes: when the purpose is understanding of natural phenomena without reference to any practical end, it has been called basic or pure research; on the contrary, when its aim is to solve a practical, specific problem, it has been named applied research. Such classification is not as clear cut as it seems at first glance. Two reasons to support such a view are: First, what is defined as a "natural" phenomenon tends to vary over time and from one social grouping to another; and second, research which is aimed at solving practical problems may result in basic understanding, and vice versa (Mulkay, 1977). However, the distinction basic-applied is useful for looking at science conceptualized as a social system.

Building on the work of Merton, Norman Storer developed a sociological construct which sees science as another primary social system, such as the family, or religion (Storer, 1966). Storer's central argument is that science has a commodity of its own, which regulates transactions among scientists. Such a commodity is recognition to scientist's work given by competent colleagues. In their search for recognition, scientists must adhere to a series of institutional norms: universalism, communality, disinterestedness, and organized skepticism (Merton, 1942).

Under this conception, legitimate members of the system of science are those people whose only concern is the description and understanding of empirical reality. Those are the "basic," or "pure" scientists. In contrast, applied scientists are tied to the solving of practical problems. This tie exposes them to developing interests in rewards other than recognition, such as money and power. Consequently, following Storer's conception, applied scientists tend to be regarded with suspicion by basic scientists, who sometimes reject applied scientists or at least do not accept them as legitimate members of the social system of science. The view of the normative structure of science was, in general, accepted uncritically throughout the 1950's and most of the 1960's, but in recent years it came under considerable criticism (Mitroff, 1973; Duncan and Zaltman, 1973). Central implications of the Storer's conceptualization is the unity and internationality of science.

It seems that Western science has been concerned since its beginning with basic and applied purposes. The statement that Nature can be mastered through understanding has been attributed to Francis Bacon. Underlying this statement are several assumptions related to Western science, e.g., that order exists in Nature, that humans can "discover" such order and translate it into scientific laws, that Nature provides the objective criteria to test the validity of scientific laws, that such laws allow humans to make predictions, and that the capacity of humans to understand and predict natural phenomena gives to people and nations unprecedented power over Nature. Such power over Nature materializes in terms of what is widely known as technology.

2. Technology: from craft to science-based technology. Not all technology, however, is science-based. Sociologists and anthropologists have used the word technology to designate in general the "know-how" that human beings have developed, wherever and whenever they have lived, which has been at the same time a by-product of and a tool for survival. In fact, in this sense, perhaps most technology used today in human affairs is not science-based.

According to Sunkel (1977) science-based technology is the result of a complex process of interaction between science and production, which took place in Western Europe concurrently with the emergence of capitalism as the dominant mode of production. He points out that in the same countries where science crystallized, there was a parallel development in production technologies, out of the crafts practiced by artisans. Crafts were gradually transformed into manufactured activities, and later into industrial production. The merger of both currents, science and production technology, constitutes what is known as the scientific and technological revolution (Sagasti, 1979).

Goulet (1975) defines technology as the systematic application of collective human rationality to the solution of problems by asserting control over Nature and over human processes of all kinds. Goulet states that implicit in his definition there are several characteristics of technology: a) technology is normally the fruit of systematic research, which is disciplined and cumulative, not merely accidental or serendipitous; b) technology is not merely intellectual speculation but rather knowledge applicable to practical problems; c) this systematically applied human reason must operate in a collective

social context, so that a practical invention which originates in a solitary mind does not qualify as technology unless it is expressed in a tool, process, or object which can be used by others; and d) technological activity aims at expanding and improving the ability of human beings to control the natural and social forces which surround them.

Technology interfaces with knowledge, but it is not totally knowledge. It has abstract and concrete components. Abstract components of technology include symbols, concepts, models, principles, theories, and laws, that together may be designated as data, information and knowledge.

In relationship to problem solving, the concepts of knowledge, information, and data may be seen as different states of refinement in a continuum of abstractions. A target problem leads the orientation of the continuum. The continuum starts with empirical facts of Nature and goes to abstractions which attempt to generalize over time and space. In this context, data are defined as the facts of Nature as perceived by humans through their senses; information is defined as data processed to solve a specific problem; and knowledge is defined as information of future use in general, not "here and now," but in any place and at any time (McDonoughs, 1963).

Technology includes not only abstract "know-how" knowledge, but physical states in which knowledge is "embodied". Hall and Johnson (1971) conceptualized technology as know-how derived from scientific knowledge and incorporated in some object, process, or activity. They say that, a) certain technologies are incorporated in concrete tools or products, e.g., fertilizers, tractors, seeds; b) process-embodied,

in turn, are technologies incorporated in plans, formulae, blueprints, and directions for processing materials into finished products, e.g., farming practices; and c) person-embodied or decisional technologies, embraces the practical knowledge used by planners, designers, managers, scientists, engineers, and technicians in analyzing bodies of data to determine what practical consequences may be drawn from them.

3. Threats and hopes related to Western S&T. Western S&T has been regarded both as a destructive and a constructive tool for humankind. In 1931, Bertrand Russell wrote a book anticipating several of the threats associated with uncontrolled S&T. He says that one of the serious drawbacks of S&T is that the power which it generates is not always accompanied by wisdom; Russell refers to "wisdom" as a sound conception of the supreme ends of human life. Russell advises not to abandon S&T, but to be sure that its utilization is guided by wisdom.

In his well known book, The Social Function of Science (1939), Bernal also treats the topic, attributing the opposition to the use of science to a blind attitude of "romantic reactionaries and conservative economists" who fail to distinguish between the necessary effects of science and its abuse.

Many others have examined the issue. Recently, Goulet (1975) points out three dangers involved in the use of S&T: a) S&T is a powerful instrument of domination, allowing its owners to exercise social control in various forms; b) it decisively affects modes of decision making; and c) it relates directly to patterns of alienation characteristic of affuent societies. From the constructive side,

Goulet sees S&T as a major resource for creating development through greater production and productivity.

In relation to agriculture, most people working in international assistance from more developed countries (MDC's) to less developed countries (LDC's) regard S&T as the route for economic growth, as the engine of change in agriculture, as an essential for agricultural development, or at least as a potential contributor to improve the conditions of the urban and rural poor in developing countries (for example, see Schultz, 1964; Mosher, 1966; Ruttan, 1971; Moravcsik, 1975; Wortman and Cummings, 1978).

B. Spread of Western S&T for Latin America.

According to Basalla (1967, p. 612) the spread of Western science to a wider world took place through military conquest, colonization, imperial influence, commercial and political relations, and missionary activity. From the 16th century through the 17th and 18th centuries, there was a constant stream of Spanish, French, German, Dutch, Swedish, and English naturalists traveling on scientific expeditions to South America, many of them as members of scientific movements wich culminated in the early decades of the 19th century in the works of Alexander von Humboldt and Charles Darwin (Basalla, 1967, p. 612).

In most Latin American countries, scientific activites started in colonial times, performed by science pioneers. They were gifted individuals, usually financed by their personal fortunes. They followed the trends imposed by the leading European scientific community (Flit, 1979). However, an autonomous community of Latin American scholars never flourished, and S&T did not root in these

societies. This anomalie is explained in terms of the dependency theory by Sagasti (1979) as follows:

> At the same time (as the rise of the scientific and technological revolution) Latin America became incorporated into an international division of labour as colonies, thus helping to sustain the industrial revolution through the supply of cheap raw materials and the provision of markets for manufactures.
>
> As a consequence of these historical processes, (Latin America) did not establish a basis of productive technologies linked to scientific findings of their own. There was no organic linkage between the development of activites devoted to generation of knowledge and the evolution of production techniques, with these two areas remaining isolated from each other.
>
> The diffusion of Western science (to these countries) was an irregular process, entailing a partial acceptance of results, but without full awareness of the cumulative process that originated them. Science in these countries was an activity limited to a few isolated pioneers whose efforts were inherently out of phase in time, since the frontiers of knowledge were being explored in other parts of the world. As a consequence, the pursuit of science did not grow roots in the majority of these countries until the first decades of the twentieth century, and even then it acquired a fragmentary and imitative character, divorced from productive sphere.
>
> The nature of modern productive activities was conditioned first by the interest of the colonial powers and then, after some regions became independent, by the way in which their economies were incorporated into the international division of labour that accompanied the expansion of the capitalist system. This meant that they were oriented primarily towards the extraction of natural resources, and to the generation of surpluses to be transferred abroad.
>
> The implanted or modern productive activities employed imported technologies that brought with them skill requirements, use of materials, organizational habits, and technical traditions that were alien to the local envirnment. Furthermore, the technological capabilties associated with modern production were expanded primarily through new technology imports, wich meant that the technological traditions--developed slowly and cumulatively over a long time--were left aside and even eliminated. This led to a reduction in the variety of indigenous technological responses.

Even admitting that dependency theory explanations are difficult to test empirically, the preceding paragraphs seem to illuminate the context in which an intensive transplant of agricultural technology was carried out from the United States to Latin America after the Second World War, via agricultural extension, or the "servicio" as it was known in several countries of the region. Such activities included transplants of product and process emodied technologies. An example of products are, tractors, fertilizers, and seeds. Some processes involved are, farming practices, and the whole conception about how to extend the new technologies to Latin American farmers. This conception was taken and directly transplanted to Latin America from the experiences which evolved in the United States Agricultural Experimental Stations.

Basic assumptions underlying the transplant of agricultural extension to Latin America were: a) technology to increase agricultural productivity was already available, the basic problem was one of communicating it to Latin American farmers; b) "rational" farmers in Latin America should adopt the new technology, as U.S. rational farmers do; c) Latin American farmers should "modernize" following the paths that U.S farmers followed; d) new technology was something inherently "good" and desirable, which would benefit any people who would adopt it; and e) powerful tools for extension were the massive communication media, e.g., newspapers and radio. All these assumptions were inadequate. Inadequacies have been widely discussed by scholars in the agricultural development literature (for

example, see Myren, 1964; Grunig, 1968; Felstehausen, 1971; Rice, 1971; Diaz Bordenave, 1976; Beltran, 1976; Rogers, 1976; Axinn, 1978).

Results of technology transplants to Latin America, via agricultural extension, started to be assessed in the 1960's through numerous studies done by members of the diffusionist school and by economists. The general appraisal of those studies was summarized by Rogers with a sense of failure in an article titled "Communication and Development: The passing of the Dominant Paradigm," which appeared in an issue of the "Communication Research" (April, 1976) entirely devoted to examining the topic.

Although all these papers are focused on the role played by communication strategies and actions, they allow one to draw a conclusion which is not confined to the field of communication, but it rather represents a general lesson: social change and modernization is a very complex process affected by many factors internal and external to the people who are supposed to be the main beneficiaries of change and modernization.

Not the most important factor, but one which, with others, is at the center of social change and modernization, is the nature of new technologies, including where and by whom such technologies were developed. It seems that some Latin American leaders and international experts involved in technical assistance programs perceived the problem very early in the stages of the extension work, and consequently started carrying out activities to institutionalize S&T for Latin American agriculture as an internal capability of those societies.

C. Insitutionalizing Western S&T for Latin American Agriculture.

1. Institution building and related concepts. The word institution has been used with different meanings in the social sciences. For the purpose of this dissertation it means a relatively organized and enduring social system that has established roots in a society in response to some basic and persistent problems.

As a social system, an institution is comprised of social relationships in intimate interplay with cultural elements. The social relationships include a set of distinct positions and the corresponding interrelations between them. Attached to those positions are sets of rights and obligations, whose meanings and definitions are tied to the cultural elements of the system and its wider environment. The set of relationships constitute the internal structure of the system, structure which is characterized by recurrent and regularized patterns of interaction among the occupants of the system positions.

Three cultural elements are central to the functioning of a social system: values, norms and sanctions. Values are generalized beliefs about what is desirable and what is undesirable in a society; such beliefs are of maximum importance because they legitimize the very existence of the system. Norms are standards of conduct which regulate the interaction among individuals in a society. Sanctions, including both rewards and deprivations, involve the use of various resources to control the behavior of persons in a society.

The basic unit of a social system is not an individual, but selected aspects of the individual's actions in relationship to the system and its wider environment. A sociological category suitable to study those selected aspects is the concept of social role. A role consists of the expected behaviors of occupants of a specific position. Social systems do not exist in a vacuum, but are embedded in larger cultures and societies. Consequently, a role is determined by internal characteristics of the system to which it belongs, and by external factors of the environment in which the system is embedded. A person who occupies a specific position learns the expected behaviors attached to that position (its social role), and at the same time interprets those expectations in personal terms. Therefore, that person's role performance includes both the role as socially defined and his/her interpretation of that role. The term role performance applies to what individuals as occupants of positions do in face-to-face or mediated, formalized or informal encounters with other people.

Institutionalization is a concept which allows one to relate a given social system (an institution) to its larger social and cultural environment. As used in this dissertation, it does not imply a fixed state but a goal, the goal of inserting a complex innovation into a society. In other words, the goal of organizing an enduring set of expectations (roles) in terms of essential components (positions, internal structure, values, norms, and sanctions) of a social system (institution). Specifically, in the context of the present study institutionalization refers to the goal of introducing Western S&T as an internal social system of Latin American nations.

During the past two decades many people and organizations have been working for the goal of the institutionalization of new or "modern" social systems in developing countries. Parallel with those activities, a conceptual framework emerged under the leadership of Professor Milton J. Esman and with contributions of numerous scholars inside and outside the United States (Blaise, 1973; Axinn, 1978). This paradigm was named "institution building" by its developers. It is strongly rooted in the concepts of social engineering, based on the proposition that the most significant, contemporary changes--especially in developing countries--are deliberately planned and guided. The word institution is synonymous to the word organization. Consequently, institution building consists of the process of designing, implementing, installing, and fostering new formal organizations or changes in old ones (Esman, 1967).

In terms of the concepts presented at the beginning of this section, institution building may be seen as a strategy to institutionalize a given social system in a society. The word institutionalizing is used here to indicate the actual process of carrying out such a strategy. Seven crucial events may appear in the process of institutionalizing a given social system: innovation, rejection, legitimation, acceptance, normality, entrenchment, and rigidity. In Axinn's words:

> The idea is that a new organization, or a change in an old organization might, at first, be seen as an innovation. It is natural for the environment to reject it. If institution building is successful, it will be legitimized, and eventually be accepted. Later, usually, it is viewed as normal in the society, and then can become entrenched. If it also becomes so rigid that it no longer serves its changing environment, new

> innovations will come along and either replace it or modify it (Axinn, 1978, p. 161).

When has that innovation become institutionalized? The conditions mentioned in the literature may be summarized in two general criteria: a) survival, and b) social value. Survival of the organizations concerned with the innovation is a necessary but not a sufficient condition for institutionalization. If organizations dissolve, the innovation will not become an institution. But they can continue operating and yet fail to be institutionalized (Esman, 1967). The innovation becomes insitutionalized when the organizations involved have demonstrated the value of its functions over time, and others have accepted those functions as important and significant. In the process, the involved organizations become more stable and secure, more capable of performing those functions and they ensure that their rising productivity is incorporated into the society's regular activities and beliefs (CEDA, 1971).

Social value is not a unidimensional and easily determinable category. It may manifest in society in several ways. For example, value may take the form of social recognition, e.g., increased or decreased prestige and monetary compensations given to the persons who perform the roles implicit in the corresponding institution. Value may also be socially expressed as increased or decreased allocation of resources, e.g., higher or lower budgets for the corresponding organizations. Another manifestation of social value is the utilization of the institution by other systems of a society, e.g., the production sector or the consumption sector. If producers use the outcomes of the institution, e.g., new technology, that is an

indication that some social value is assigned to the functions of the institution in that society. Consumers also may indicate the value they assign to the institution, by accepting or rejecting the goods and services, e.g., food products, which incorporate outcomes of the institution.

In summary, an innovation has been institutionalized in a society when it has developed deep roots in the functioning of that society. In return, the society shows appreciation (value) for the new functions by supporting the institution in a variety of ways. But this process does not take place easily or quickly. The process of social change that steadily evolved and resulted in the Western institution of S&T took place in a series of small steps, the cumulative effects of which were not apparent to their initiators. Increasingly complex and formal organizational structures emerged as the cumulative consequence of their activities at the grass roots level (Morse et al., 1969).

However, as pointed out by members of the institution-building school, institutionalization need not be a "natural" or evolutionary process, which occurs independently of deliberate human will and direction. Institutionalization, in present times, is achieved "by design" and typically following an "inverse model." In this case the hope is that eventually the set of new or reformed organizations or "institutes" will evolve in well-established and structured constellations of roles which fulfill specific functions for societies or groups within societies, and which will be valued as "natural" institutions, such as family or religion.

In the long route to institutionalization, an essential requisite will be to secure continuity to the operation of those organizations. And continuity will probably not be sufficient. Changes and "institution building" in other aspects and sectors of the concerned societies will be necessary. In recent days, a general preoccupation of LDC's leaders has been not only to have available internal S&T capabilities, but to be sure that those capabilities are indigenous. That means to have control of the whole process of S&T importing, testing, adapting, generating, and utilizing (for instance, see documents of the "Group of 77" to the 1979 United Nations Conference on Science and Technology for Development, Vienna 1979; and the Background Study on Suggested U.S. Initiatives for the same conference).

In Latin America the regional Organization of American States has been concerned with the topic for years. Its work has concentrated on the development of national S&T policies. In relationship to agriculture an important action has been the establishing of and permanent support of the Instituto Interamericano de Ciencias Agrícolas (IICA), which has conducted social and biological research and largely contributed to the development of indigenous human S&T capabilities through its Turrialba Graduate School.

A very influential work with respect to institutionalization of science in Latin America has been the concept called "Sabato's triangle," which is based on the proposition that the development of indigenous S&T is the result of a deliberate process of interrelationships among the vertices of a triangle: the government

vertex, the vertex of S&T infrastructure, and the productive structure vertex (Sabato and Botana, 1975). Following a similar line of thought, Sagasti (1979) has identified three groups of actions necessary for the development of indigenous S&T capabilities in Latin America: a) the expansion and reorientation of the S&T system, b) the selective and systematic recovery of the traditional technological base, and c) the transformation of the productive system.

In general, it may be said that the design of strategies to institutionalize Western S&T in developing countries may result in different modalities of institution building. For instance, in centrally planned economies of socialist countries, the strategy may consist of building a centralized governmental organization. In mixed and market economies, it may be to build a set of public and private organizations. In a predominantly market economy, it may put emphasis on private organizations whose survival will depend on the profitability of their outcomes.

With reference to Latin America, a set of strategies and actions for institutionalizing S&T were initiated in the post-war period, and since then they have been dynamically evolving. Such actions were initiated with participation of national leaders and supported by the U.S. Department of Agriculture and Rockefeller Foundation. Later on, other governments and private organizations joined the enterprise.

2. Actions for agricultural research in Latin America. Attempts to institutionalize Western S&T for Latin American agriculture appear to have started during the 19th century and the first part of the present century, but appropriate documentation was not found in the literature search carried out for this dissertation. In Latin America

there are S&T agricultural organizations whose foundations are traced to that period. For instance, the Escuela Nacional de Agricultura de Chapingo, Mexico, installed during the first years of the Mexican Revolution, has it roots in the Escuela Nacional de Agricultura de San Jacinto, founded in 1854 (Fernández y Fernández, 1976; Gómez, 1976). Pichilingue, in Ecuador, which was originally tied to plantation crops like banana and cacao, took in 1943 the name of Estación de Investigación Agrícola del Ecuador, and in 1963 was incorporated to what today is the Instituto Nacional de Investigaciones Agrícolas y Pecuarias, INIAP (EMA and AID, 1979).

a. Special Studies Offices. The efforts to install S&T capabilities for agriculture in Latin America with U.S. assistance started with the organization of Special Studies Offices, which appeared in several countries like Mexico and Colombia. In terms of Hall and Johnson's typology, those programs began with a transfer of person-embodied technologies represented in the staffing of those offices with well-known agricultural scientists like Richard Bradfield, P.C. Mangelsdorf, E.C. Stakman, J.G. Harrar, and Norman Borlaug. Subsequently, the development of indigenous human S&T capabilities started with in-service training programs and with the sending of promising young nationals to U.S. universities, in order to continue their education at Master's and Ph.D. levels (Wortman and Cummings, 1978).

b. National Agricultural Research Institutes. Out of these seminal experiences, a process of institution building was initiated in the late 1950's. Most of the present Latin American national agricultural research institutes come from that time. With small

variations, but within the same general organizational model INTA was created in Argentina in 1957, INIAP in Ecuador in 1958, INIA in Mexico in 1960, ICA in Colombia in 1962, INIA in Chile in 1964, and EMBRAPA in Brazil. More recently, in the 1970's, four additional national institutes appeared in the scenario: IBTA in Bolivia, ICTA in Guatemala, INTA in Nicaragua, and INIA in Peru (Trigo, Pineiro, and Ardila, 1979).

The organizational model for Latin American national agricultural research institutes was inspired in the experiences generated during more than one hundred years in the U.S. Land Grant Colleges. At the core of the lessons learned from those experiences is the principle that education, research and extension are parts of the same continuum, and that it is not convenient to have them separate. This feature of the model was difficult to implement. Most Latin American institutes are devoted only to research, with exclusion of the other two functions.

The closest example to replicate the model seems to be the Colombian case. There the Escuela de Graduados de Tibaitatá, which has been conceptually linked to the Universidad Nacional de Colombia, was operationally attached to the Instituto Colombiano Agropecuario (ICA). Within its multiple responsibilities, ICA has the other two functions: research and extension. Another example, but far more different, took place in Mexico, where three separate organizations corresponding to the three functions had a common home for their central offices in the same physical place. They are the Colegio de Postgraduados de Chapingo (education), the Instituto Nacional de Investigaciones Agrícolas, INIA, (research), and Extensión Agrícola

(extension). This arrangement, however, did not last, and at present each organization has its own home at a different place. The Peruvian is a third case, where at present the establishing of a national research institute (INIA) is taking place in close connection with the Universidad Agraria La Molina.

c. International Centers. A further phenomenon which appeared in the Latin American scenario of Western S&T institutionalization was the "invention" of the international agricultural research center (IARC). According to Wortman and Cummings this model grew out of the accumulated experience of many organizations and individuals over half a century. Examples of organizations which provided inspiration for the model are the Experiment Station of the Hawaiian Sugar Planter's Association, the Pineapple Research Institute of Hawaii, and the Central Rice Research Institute of India. Typically, international centers are production oriented, and use a multidisciplinary problem solving approach to remove the more critical restrictions of biological nature which limit productivity increases of a single crop.

Wortman and Cummings (1978, pp. 131-133) point out eight attributes as the unique characteristics of international agricultural research centers: 1) each center is governed by an autonomous, self-perpetuating board of trustees; 2) international centers are staffed by the best talent available, regardless of nationality, and they are being increasingly accepted by nations of diverse ideologies as apolitical institutions; 3) they are mission-oriented (the mission being to help nations develop their capabilities to increase agricultural production); 4) a center can initiate a new program

quickly; 5) international centers have unusual flexibility in responding to national requests, flexibility which enables them to arrange cooperative programs on a scientist-to-scientist basis as well as an organization-to-organization basis; 6) training of national S&T personnel is central to the conception and operation of international centers, and they can tailor training to fulfill specific needs; 7) international centers support institutionalization of S&T by keeping their staff acquainted with advanced work done anywhere in relationship to their research programs, by systematically collecting and preserving the associated knowledge and materials, and by making the knowledge and materials available to all organizations and persons; and 8) international centers are financed by a growing number of national and international assistance agencies financial support which allows them to have continuity of research work.

The system of international centers began with the International Rice Research Institute, established in the Philippines in 1960. In 1978 this system was integrated by twelve centers, three of them operating in Latin America: the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) founded in Mexico in 1966, the Centro Internacional de Agricultura Tropical (CIAT) in Colombia in 1969, and the Centro Internacional de la Papa (CIP) in Peru in 1972. Financial support for the entire system is coordinated through a consortium of donors, the Consultative Group on International Agriculture Research (CGIAR). This organization evolved out of a meeting at Belagio, Italy, in 1969, where leaders of some of the world's major assistance agencies decided to concert their resources for the expansion of the activities of the four existing international centers, and for

establishing new ones as might seem appropriate (Wortman and Cummings, 1978; IADS, 1976, 1977, 1978, 1979, 1980, 1981).

Wortman and Cummings see international centers not as isolated corps, but as components of a worldwide research network, which has three interlocking components: national research and production systems, the international agricultural research centers, and research organizations of more developed countries (Wortman and Cummings, 1978, pp. 127-135).

During the last five years, the system of international centers has been enlarged with the creation of two new organizations, specialized in providing assistance to nations interested in developing indigenous S&T capabilities for agriculture: the International Agricultural Development Service (IADS) initiated by the Rockefeller Foundation in 1975, and the International Service for National Agricultural Research (ISNAR), established by the CGIAR in 1980. IADS, with headquarters in New York, offers assistance in agricultural planning, strengthening research systems, training personnel, and implementing production programs (IADS, 1981, preface). ISNAR, with headquarters in the Hague, Netherlands, has as its ultimate goal "to enable developing countries to plan, organize, manage, and execute development-oriented research more effectively from their own human, natural, and financial resources, supplemented where necessary by effectively incorporating external resources" (Gamble, 1981, p. 6). As emphasized in the objectives of both centers, the development of human capabilities is one of the main limitants in the building of indigenous S&T organizations.

D. Developing human S&T capabilities for Latin American agriculture.

1. Training opportunities. Training for providing Latin American agriculture with its own S&T capabilities started in a systematic way in the 1940's with several different approaches to educational system development: in-house in-service training, followed by postgraduate training at Master's and PhD levels in MDC's, mainly carried out in U.S. universities and to a lesser extent in Europe. At the same time the building of agricultural higher education organizations was initiated in the region. Many such programs began parallel to the efforts of building national agricultural research institutes, and heavily relied on external sources for financial support. It was expected that internal monies would gradually replace external aid, to eventually gain a relative self-reliance (Trigo, Pineiro, and Ardila, 1980).

Perhaps the oldest Latin American center for degree postgraduate training is the graduate school of the Instituto Interamericano de Ciencias Agrícolas (IICA) which has operated in Turrialba, Costa Rica since 1946. The building of IICA started in 1940 as an initiative of the Organization of American States (also known as the Pan-American Union), which appointed an Inter-American Committee on Tropical Agriculture. This committee obtained the consulting assistance of a U.S. Department of Agriculture Committee, which, after visiting Latin Ameican countries, suggested Turrialba as the appropriate site for the field headquarters. Naranjo (1966) says that it is hard to distinguish the graduate school from the total structure of IICA during its initial years. In his opinion, IICA basically appeared as an organization devoted to teaching and research in agriculture and related fields, in order to encourage and promote the development of

agricultural sciences in Latin American countries. In 1946 the IICA Graduate School started with eight students from Bolivia, Colombia, Costa Rica, Guatemala, and the Dominican Republic.

Associated with the national research institutes, the following graduate schools have been in operation: the Colegio de Postgraduados de Chapingo in Mexico, the ICA-Universidad Nacional Programa de Graduados (PEG) in Colombia, and the graduate school of INTA in Argentina. A tradition of agricultural postgraduate studies existed and has continued in the Universidad Agraria La Molina in Peru. In addition, postgraduate programs have been established during the last two decades in universities of Brazil and Chile.

These efforts for developing human S&T capabilities have been complemented with non-degree training programs carried out at different organizations of MDC's and within the region, particularly at international agricultural research centers. At IARC's there is a wide range of training opportunities from in-service internships to post-doctoral fellowships (see Table 1, based on Fernández, 1977). Although some of these opportunities involve fieldwork for Master's and PhD theses, it may be classified as non-degree because IARC's do not grant academic degrees.

2. Training follow-ups. Concerns wih effectiveness and relevance of such training efforts have resulted in several follow-up studies. Emphasis on topics has ranged from attitudinal studies to cognitive aspects of work performance, but a dominant theme has been the so-called "brain-drain." No studies were found in relationship to the participation of former students in third cultural networks of S&T in Latin America.

Table 1. Training programs offered by CIMMYT, CIAT, and CIP, in 1976, 1977 or 1978.

Program	International center		
	CIMMYT	CIAT	CIP
In-service internships in research	X	X	X
In-service internships in production		X	X
In-service internships in management of station operations	X	X	
Short internships on special research or production skills		X	
Summer students trainees (undergraduates)		X	
M.S. thesis research	X	X	X
PhD dissertation research	X	X	X
Advanced research fellowships (visiting research associates), post M.S.	X	X	X
Postdoctoral fellowships	X	X	X

Adapted from Fernandez, 1977.

In 1966 Naranjo followed up the opinions of former IICA graduate students for a period of nineteen years, regarding the value and achievement of the school's educational objectives, academic program and related aspects. Naranjo's most important findings were, a) a high value was awarded by graduates of IICA's school; b) graduates recognized that IICA has met its educational objectives in an appropriate way; c) Turrialba school strengths consist of an ideal combination of teaching and research, endowed with good library facilities and faculty with PhD degrees and research experience; d) most of the graduates following doctoral studies in U.S. universities have received recognition for their "Magister" degree granted by IICA; and e) job dissatisfaction among the IICA graduates as expressed by them was very low.

Another follow-up study about former students' opinions on their training program was carried out by Morris (1974) about CIAT's training programs. The main conclusions were, a) there were problems in the process of trainees' recruitment, mainly associated to lack of and vagueness of pre-interview information for potential candidates and institutions; b) the selection process presented weaknesses in terms of the role that trainees' home institutions played in selecting candidates; c) the area of planning training to fit specific needs of individuals and institutions was considered one of the major weaknesses in CIAT programs by both staff and trainees; d) many trainees expressed their need to have more involvement with small farmers in trainees' learning activities; e) trainees were in general very satisfied with the length and level of their training; f) practical experience was by far the most valuable aspect of the training period as pointed out by trainees; g) in estimating the

degree to which they believe they are applying their training in their work, 59% indicated extensively, 27% said moderately, 10% thought little was applicable, and 4% none; and j) the trainees assigned a high value to the opportunity they had while at CIAT to meet other research workers from throughout the region; 93% indicated they have since had some contact with such new acquaintances and 74% of these were to some extent professional in nature.

Swanson's study (1974) compares the training approaches of CIMMYT and IRRI, as well as a set of aspects of the training aftermath of professionals who attended research and production programs at those two centers. Swanson's main concern is the internalization of the normative structure of science by foreign students who are trained at MDC's universities. His central research question is: Can the international agricultural research centers offer the type of training that will result in trainees working to solve local production problems? Swanson found that a training which emphasized knowledge-generating types of reseach resulted in a job performance characterized by a relatively high output of technical research papers; in contrast, a training which stressed technology development led to trainees' performance more oriented toward the production processes and problems. He concludes that serious organizational bottlenecks may occur in national research and extension programs due to the lack of appropriately trained personnel.

With reference to degree training in the United States, Fienup and Riley (1980) conducted a worldwide survey among agricultural economists from developing countries. Their main conclusions were, a) students from LDC's represented 30 percent of the total of new entrants in U.S. university graduate programs in agricultural

economics over the period 1969-1977, the largest absolute numbers being from Asia and Latin America; b) 82 percent of the survey respondents were still living and working in their native regions, but the percentage ranged from 73 percent in Asia to 85 percent in Africa and 90 percent in Latin America; c) U.S. graduate training in agricultural economics is highly regarded by LDC alumni and their employers; d) the traditional professions such as law, medicine and engineering are typically better developed and more prestigious in Latin America than those in agriculture; e) although there is a sizeable number of trained agricultural economists in Latin American countries, significant capabilities for graduate-level training currently exist only in Brazil, Chile and Mexico; graduate training programs that were developed in several other Latin American countries during the 1960's have either ceased or have become very weak. Based on their own and former studies, Fienup and Riley (1980, p.87) suggest adopting three broad goals which provide a general orientation to the profession of agricultural economics in relationship to international development:

1) To substantially increase LDC professional capacities to train agricultural economists at the M.S. level and to conduct research and related extension programs on agricultural and rural development programs.

2) To strengthen the U.S. university faculty capabilities to train LDC and U.S. professionals for effective international development work.

3) To establish and maintain professional networks of LDC, U.S., and other deveoped-country agricultural economists that would facilitate collaborative programs of research, education, and public service.

3. PROTAAL, an in-depth, comprehensive research project on S&T in Latin America. A major research project focused on the nature of the technological processes involved in Latin American agriculture has been pursued by IICA with the cooperation of the Ford Foundation, the United Nations Development Program (UNDP), and the International Development Research Center (IDRC) of Canada. Its name is Proyecto Cooperativo de Investigación sobre Technología Agropecuaria (PROTAAL). It started operations in January, 1977, and has developed conceptual and methodological frameworks; conducted in-depth case studies in Colombia, Argentina, and Perú; and published preliminary reports. PROTAAL looks at technological processes as endogenous phenomena, inherent to the society in which they develop. Its aim is to understand the problem and subsequently to suggest policies, organizational models, and actions to contribute to agricultural development in the region.

Most of PROTAAL initial work has been concerned with the development of indigenous S&T human resources for Latin American agriculture. In view of the fact that the researcher plays an extremely important role in S&T activities, PROTAAL, at this initial stage, has emphasized the study of the development of human resources for S&T, as a necessary condition for putting in operation all the other infrastructural components.

The main findings of the project so far increasingly suggest that a serious deterioration of the national reserch an éxtension institutes is generalizing in the region, with the exception of Brazil, Venezuela and Mexico. Associated to such deterioration there

are many factors in one way or the other tied to the historical background of those societies and the resultant duality of their economies. Such duality has impact on the research institutes via changes in national policies, sometimes emphasizing commercial agriculture and at other times, traditional, subsistence production.

Three components of the problem have been indentified; a) from the time in which the national institutes were established, starting in the late 1950's, a change in emphasis of national development policies has occurred, passing from importance of technology for commercial agriculture to importance of structural changes such as land redistribution (agrarian reforms), and from these reforms to rural development focused not on production but on welfare; b) the biases of science-based technology, which is neutral only in some components, e.g., new varieties, but which at the level of whole production systems favors commercial production; and c) the rise of alternative source of technology at the national level, tied to agricultural input industries, organizations of commercial agricultural producers, and agribusinesses.

Deterioration of the national agricultural research institutes is manifest, according to PROTAAL findings, in the decreasing social value of research, e.g., lack of political support, decreased budgets, and so on. This complex of forces has affected the development of human S&T capabilities in three ways: a) the postgraduate schools are ceasing to exist (see Table 2); b) the national institutes are losing their human resources by changes to non-research activities or migration to other organizations and countries; and c) there is a high

Table 2. INTA, ICA, and Universidad Agraria de La Molina: Personnel who initiated postgraduate studies in general and in the national programs (1965-78).*

YEAR	INTA		ICA		LA MOLINA	
	Started studies	National program	Started studies	National program	Started studies	National program
1965	15	2	11	-	15	2
1966	22	3	22	-	13	2
1967	34	-	24	8	27	1
1968	28	10	35	7	24	6
1969	23	2	40	8	16	2
1970	21	5	51	15	20	4
1971	39	21	37	8	10	3
1972	24	8	110	59	10	1
1973	24	16	96	52	11	5
1974	4	-	57	40	13	5
1975	1	-	53	51	7	1
1976	2	-	28	23	6	2
1977	1	-	7	-	1	-
1978	-	-	4	3	-	-

*Source: Trigo, Piñeiro, and Ardila (1980, p. 10).

rotation in research posts, with the consequent lack of continuity in research work and loss of opportunity for researchers to develop more experience and professional maturity (Trigo, Piñeiro, and Ardila, 1980; Ardila, Trigo y Piñeiro, 1980; Trigo, Piñeiro, and Ardila, 1979; Ardila, Trigo, Torres, Piñeiro, and Rincón, 1980; Ardila, Torres, and Trigo, 1980; Ardila, Reichart, and Rincon, 1980; Piñeiro and Trigo, 1977).

Trigo, Piñeiro, and Ardila (1980) see IARC's as a contextual element which may have had influence in the deterioration of national agricultural research institutes. Three possibilities are, a) the rise of IARC's implied a loss of international financial support to national institutes; b) the perception of IARC's by users as an alternative source of S&T may have contributed to loss of political support to national institutes; and c) IARC's may be affecting the research priorities as defined by national institutes, which do not necessarily coincide with the research priorities of IARC's.

The above-mentioned studies throw doubts on the viability of institutionalizing indigenous and endogenous science capabilities for the agriculture of the region. Figures about the evolution of agricultural research expenditures show increases from (in U.S. dollars) 73 million in 1965, to 146 million in 1971, and to 170 million in 1974. These figures allow one to think that agricultural research is receiving increasing priority as a basic function of these societies. Nevertheless, Latin America continues to rank last among the regions of the world in terms of research expenditures as a percentage of the value of agricultural output (see Table 3, from a study by Boyce and Evenson, 1975).

Table 3. Agricultural research expenditures and expenditures on research as a percentage of the value of agricultural product, by region (1965-74).*

Region	Total annual expenditures (millions of 1971 constant US$)			Percentage of total research expenditures to value of agricultural product		
	1965	1971	1974	1965	1971	1974
Western Europe	407	671	733	1.4	2.0	2.2
Eastern Europe & USSR	627	818	861	1.5	1.7	1.8
North America & Oceania	806	1203	1289	1.9	2.6	2.7
Africa	114	139	141	1.3	1.4	1.4
Asia (excluding China)	356	610	646	1.2	1.8	1.9
Latin America	73	146	170	0.6	1.1	1.2
Total	2383	3588	3841			

*Source: J. Boyce and R. Evenson (1975).

Another perspective for looking at these phenomena has been emerging, based on studies of the sociology of science and on Useem's sociological construct about third cultural networks of science and technology.

E. Social structures and third cultural networks of S&T.

1. Notion of network. Network is a word commonly used in the daily language. It can suggest a structure of cords, threads, or wires that cross each other at regular intervals and are knotted or secured at the crossings. It can indicate a set of lines or channels that interlace, like a network of highways, a network of rivers, or a network of veins. Sometimes this word is used to describe a system of electrical conductors in which electricity flows between certain points by more than one path, e.g., a network of telephones. Today it is common to hear about networks of radio, networks of television, networks of computers, and so on.

With regard to scientific research, the words "research network" may refer to a variety of entities such as networks of papers, networks of authors, networks of libraries, networks of organizations, or networks of experiments. In this dissertation the concern is with networks of persons in which the nodes are individual researchers or groups of researchers, and the links are relationships among reseachers. With this meaning, the words "research networks" are used here interchangeably with the words "networks of reseachers."

2. Research networks: organization among S&T professionals. The study of social organization in science has been a research area in which sociologists have focused particular interest during the last

twenty years. The first empricial studies, to the knowledge of the author of this dissertation, came from the early 1960's when Derek de Solla Price (1963) started looking for evidence about the existence of organization in science. He studies mutual citations which appeared in published research papers. Later studies concentrated not on the formal communication system of science (the scientific journal and related printed media), but on the multitude of personal contacts through which researchers keep themselves up to date on the work of their colleagues.

Diana Crane (1972) found evidence about the existence of some groupings with clear functions in the production of research. She regarded those groupings as "natural" organizations and called them "invisible colleges," following Price's use of the term in former writings. Price had taken the term from writings of the early Royal Society of London. An author attributes the first use of the term "invisible college" to Sir Robert Boyle. According to Greene (1969) Boyle used that term to distinguish his own group from the visible Gresham College.

a. Social structure among researchers. The conventional conception of science saw research as the activity of an individual pursuing one-sided dialogue with Nature. However, studies from sociology of science suggest that research is rather a corporate activity. Starting from a macro perspective, three concepts help look at the social structure among researchers: research community, research networks, and research groups (see Figure 1).

i) Research community. This is the all-encompassing concept. The research community comprises all those persons who occupy research positions in their societies as a central part of their professional

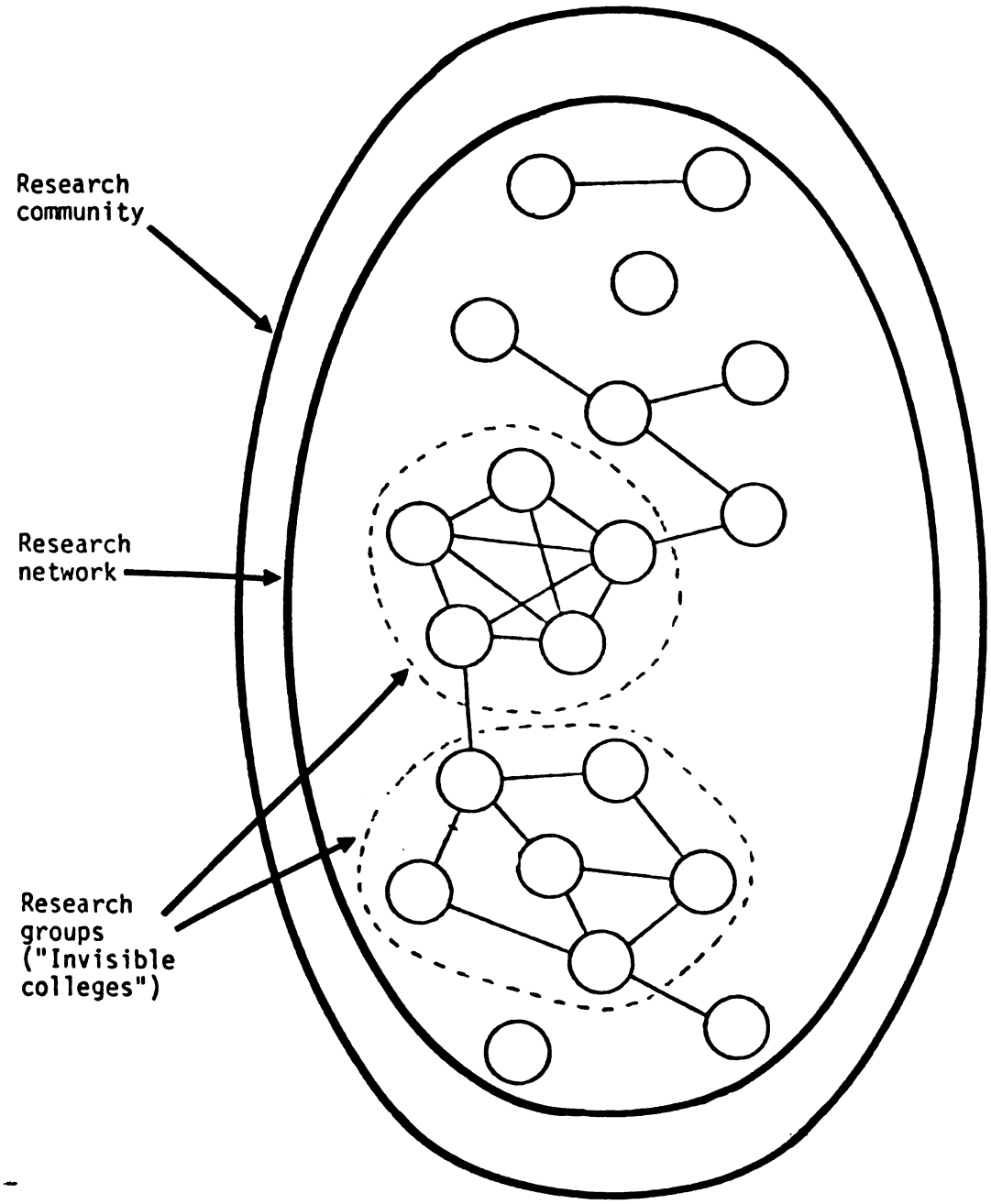

Figure 1. Research community, research network, and research groups.

activities. There is no distinction in this definition about "basic" or "applied" researchers. It simply allows one to identify in a given society who are and who are not members of the research community. However, the research community is not a uniform entity, but a multitude of loosely defined subsets. A central feature of the research community which will be treated in the final section of this chapter is the tendency of its members to transcend national boundaries and to create third cultures in terms of their cognitive interests and cultural backgrounds.

ii) Research networks. This is a concept which looks for a more workable specification of subsets of the research community. Subdivisions based on distinctions between science and technology, between basic and applied research, or between disciplines and specialities are too ambiguous to provide a coherent focus for studying social organization among researchers (Mulkay, 1977). Such a focus is provided by much smaller sets of reserchers, who are concerned with a fairly narrow range of closely related problems (Law, 1973). These sets are conceptualized as problem networks, within which basic processes of innovation and social control in science take place (Mulkay, 1972; Crane, 1972). Under this conceptualization, the basis of establishing the boundaries of a reseach network is a cognitive goal: the research problem. Given that a reseach problem may be perceived in different ways and from different perspectives, it seems more appropriate to talk about sets of closely related problems rather than about a well defined specific research problem. Therefore, research networks are defined here as subsets of the research community integrated by researchers whose attention is focused on closely related problems.

Diana Crane uses interchangeably the terms "communication networks" and "invisible colleges." In this dissertation the word network has been associated with a wider entity which includes members of invisible colleges and people playing other roles, such as "liaisons" and "isolates." Thus, the term research network is used here to communicate the idea of sets of researchers interested in closely related problems, but without the requirement that they all constitute a group, be aware of each other, be present in the same place, belong to the same formal organization, have direct relationship with each other, nor that they develop clear leadership. All these circumstances could be present within a network but they are not necessary conditions. The term "invisible colleges" is used here as synonymous to "research group."

iii) Research groups. Several studies have identified a tendency among the most productive and influential researchers of a field to develop intensive communication interchanges among themselves (for instance see Price and Beaver, 1966; Garvey and Griffith, 1967; Crane, 1972). These are members of invisible colleges, called here research groups. Price (1963) argues that such groups are an inevitable product of the remarkably rapid exponential growth in he number of scientists and in the size of the literature. Research groups play prominent roles in the development of research networks and in the institutionalization of S&T. Indeed, they provide leadership and orientation within their own research network (Crane, 1972), they represent their field in the wider research community, and they contribute to gain social recognition for S&T activities (Cole and Cole, 1968).

Research groups are operationally defined here as "communication groups" in the terminology of communication network analysis. Communication groups are composed of members whose communication is devoted more to each other than to persons outside the group, and to group linkers who serve the function of uniting or binding two or more groups, thus moving messages from group to group (Farace et al., 1977, p. 185).

iv) Network structure provides a basis for looking at the internal dynamics of research networks. The patterned set of relationships among researchers is what allows one to talk about a paticular set of researchers as a network. If there are no relationships, there is no network.

Relationships among the members of a network can be studied in terms of different dimensions, such as power and communication. Communication relationships among researchers have received preferential attention from sociologists, perhaps because it is considered that authority relationships are contrary to the professional norms which underlie scientific activity (Hagstrom, 1965) and scientists are supposed to advise and criticize but not to command each other (Crane, 1972), or because in communication processes, with the flow of messages is also conveyed a flow of influence.

The fact is that researchers behave differently as communicators, and that different communication behaviors result in the establishment of different sets of relationships within a network. When interaction is repetitive over time, it is likely that some regularities or "patterns" appear in the configuration of those relationships. Such regularized patterns of relationships constitute the sturucture of a network.

b. Cultural elements within research networks. In the preceding section a conceptual framework was presented for looking at social relationships among researchers. This framework regards networks of researchers as social systems. The conceptualization is complemented in this section with three cultural elements of research networks: values, norms, and sanctions.

i) Values. With reference to the above-mentioned three cultural elements of networks of researchers, the following framework is mainly built on the works of Kuhn (1962) and Ziman (1968). The central point here is that values, norms, and sanctions in research networks are highly influenced by general agreement or consensus which is created within invisible colleges.

In his book, The Structure of Scientific Revolutions, Kuhn provides a perspective for examining the issue of consensus in science. He conceives the emergence of general levels of consensus in science as a result of interaction processes among researchers who share specific definitions about their work. Thus, members of research groups establish criteria and standards to govern their own research field. They constitute "paradigms" which influence the setting of research priorities and the selection of appropriate techniques and procedures to conduct research in their own field. Therefore, what is to be regarded as a significant research problem and the decision about what is the appropriate methodology to study it, more than an "objective" issue, is a value socially shared by a specific group of researchers.

From this perspective, the dominant values in a particular research network may be seen as negotiated and imposed under the pressure of the most influential researchers of the network. If they are well connected with other networks and other social systems, those influential researchers will represent not only the views within networks, but views predominant in other research networks, and views about the role of science in society held outside the research community by influential members of researcher sponsor groups, governmental agencies, political movements, and so on.

The values shared by sets of researchers result in some degree of consensus among them about their research activities. Consensus among researchers is not based on the universal right to vote, the key principle of political democracy, but in the agreements of scientifically competent persons.

How can such a system avoid falling into a self-penetrating pattern of doctornal orthodoxy and error? Ziman (1968) says that the protection against a self-penetrating circle in science is the size of the scientific community and the interlocking of the various fields so that new critical attitudes, expertise, and ideas can always percolate from one grouping to another, allowing for correction of local errors.

Because invisible colleges are not organized on any a priori plan, they overlap one another in a multidimensional array, so that many scholars find themselves at the junctions of two, three, or more fields. The problem of creating a consensus of ideas becomes transformed into the creation of a consensus on the personal standing and credibility of the individuals who speak for these ideas.

In the following paragraph Ziman points out his view about the role of consensus in science:

> What I have tried to show. . . is that the criteria of proof in Science are public, and not private; that the allegiance of the scientists is toward the creation of a consensus. The rationale of the "scientific attitude" is not that there is a set of angelic qualities that guarantee the validity of their thought--as if they were, so to speak, well-tuned computing machines whose logical circuits precluded them from error--but that scientists learn to communicate with one another in such tones as to further the consensible end to which they are all striving, and eventually train themselves to construct their own internal dialogues in the same language. A private psychological censor takes over from the policeman or parent, and conforms our behavior to social norms. But he does not keep whispering into our ear, "Be honest, be objective," in a chorus of pious aspiration; he says, "Have you checked for instrumental errors? Is that series convergent? Would anyone understand that sentence? What is the present status of that old bit of theory?" and so on (Ziman, 1968, p. 78).

Consensus is also seen in this thesis as influencing the norms and sanctions predominant in a research network.

ii) Norms. In his formulation about the norms of science, Merton (1942) argued that the extension of scientific knowledge is possible only in a community where there is widespread conformity to four institutional imperatives: universalism, communality, disinterestedness, and organized skepticism. Universalism requires that information presented to the scientific community be assessed independently of the personal characteristics of the source of information; communality requires that scientific knowledge be held in common, for scientific information belongs to the scientific profession and not to those who were resonsible for its discovery; disinterestedness requires that researchers pursue scientific knowledge without considering their career or reputation; and organized skepticism requires never taking results on trust.

Scientists should be consistently critical of their own and others' research.

Two additional norms appear in the writings of Storer (1968) who built upon the works of Merton and Barber (1963): rationality, which requires that reason guide all scientific work; and emotional neutrality, which requires that data are not distorted, and research approaches are not taken in an inflexible way.

Mertonian norms of science are expressed at a very abstract and idealized level. These norms were in general accepted uncritically throughout the 1950's and most of the 1960's, but in recent years they came under considerable criticism (Mitroff, 1973; Duncan and Zaltman, 1973).

Restivo (1971, p. 119) suggests that "the norms, whatever their origin, are today part of an ideology among scientists that has emerged concomitantly with the professionalization and bureaucratization of scientific activities."

Ziman (1968, p. 96) regards norms as consequences of consensus among scientists. In this sense, the persons participating in a research network develop and interpret their own sets of norms and standards, which may or may not be tied to a worldwide, generalized ideology of science.

iii) Sanctions. Mulkay (1977) says that it has become widely, although not universally, accepted by sociologists that recognition by competent colleagues is the basic reward within the research community.

To admit that recognition is the main reward for doing research does not necessarily imply that other rewards such as professional

promotion and increases in salaries are not within the motivation of scientists. These may be results of higher reputation, achieved via recognition by comptent colleagues.

Quality of research is suggested by Mulkay (1977) as the most important single determinant of recognition. In other words, professional rewards seem to be distributed partly in response to the amount of information that participants supply to the research community, but more significantly, on the basis of the perceived value of this information.

However, the value of the information will be determined by the consensus about what is considered "good research," "appropriate technique," etc., in particular research networks.

With reference to agricultural research in developing countries, Swanson (1977, pp. 338-340) regards as problematic the reward system for producing science-based technology. Swanson suggests that a substantial number of agricultural researchers in these countries might give first priority to individual projects with potential for publication in journals of more developed countries, but not necessarily relevant to the needs of their societies. He supports his view with the following factors: First, many research workers in the LDC's obtained their advanced degrees at universities of MDC's, where they were socialized in a "publish or perish" tradition which usually rewards only theoretical inquiries. Second, economic compensations, but not professional recognition, constitute the main reward system of agricultural research organizations in LDC's; increased in salaries are assigned according to bureaucratic procedures and criteria, but not according to the type of research carried out. The third factor

relates to the social status of agricultural activities. Swanson says:

> in most cultures agricultural work is considered a low-status occupation; therefore, there are no positive social rewards to encourage a highly trained research worker to work on practical problems--the result of which would be of direct importance only to a peasant or cultivator and which would not result in any significant professional recognition. Even if individual scientists were motivated to do this type of research, the research organization has no effective way formally to reward such successes.

Finally, Swanson points out why he thinks that the reward system of research in LDC's would make agricultural researchers prefer individual projects over teamwork. To develop science-based agricultural technology requires the cooperation of specialists in various disciplines, but the credit accrues to the team, not to the individual. "If this team credit is usurped by the research director or the team leader, instead of being shared by the team members, individual research workers will not be encouraged to work together on future endeavors" (Swanson, 1977, p. 340).

3. Third cultures of S&T. During the last two decades John and Ruth Useem have developed a paradigm for the study of cross-cultural interactions. The focus of their attention has been on the new social structures and cultures which emerge out of the interchanges among members of different social systems in our present, increasingly complex, conflicting, and interdependent world. Those communities which have no national or geographical boundaries have been called "third cultural networks" by the Useems. Following are presented the aspects of Useems' conceptualization which are relevant to this thesis. The first part deals with the concept of third cultures, and

the second one makes reference to a specific kind of those cultures, the third cultures of science.

a. The concept of third cultures refers to the patterns of "relationships (including norms and values) created, maintained, and shared, generic to communities of men who related their societies, or segments thereof, to each other" (Useem, 1963). Third cultures reflect the cultural backgrounds of their creators and impinge on themselves and on segments of their societies:

> Third cultures are created, carried and changed by persons who are relating segments of one society with segments of one or more societies. Although affected by macro-level changes in the relationships between societies and by redefinitions of the position of the segment within a society, still each third culture has a history of its own which can be traced. These third cultures, in turn, impact on other segments of societies through the roles which carriers play (Useem, Useem, Othman, and McCarthy, 1980, p. 4.)

Implicit in the above-stated concepts are several features inherent to the third cultural paradigm. First, the unit for cultural interchanges between societies is the individual human being. The carriers of "third cultures" are "individuals who have received a modern and high education, have an occupation or a profession that is part of the modernizing-developing nation-building institution, and typically have been recruited as adults" (Othman, 1977, p. 6). Second, third culture creators and carriers do not act in a vacuum, but they are "embedded" in particular settings. With respect to these two features of their conceptualization the Useems and some of their disciplines recently emphasized:

> We discern one largely neglected yet crucial domain in most discussions, namely, recognition that world systems, policies, and programs are carried out by individual human beings, whose lives, scientific careers and professional roles are embedded in particular historical,

economic, technological, and political settings (Useem, Useem, Othman, and McCarthy, 198, p. 3).

Third, the interchanges among members of third cultural networks are personalized but do not require face-to-face interaction. Fourth, what holds these networks tegether is sharing of interests, but not kinship or location; particular networks may emerge around a variety of transnational interests, e.g., religion, ideology, political movements, business and industry enterprises, science and technology endeavors, and so on. These two aspects of third cultures arise from "the ability of people, widely scattered around the world, to maintain and sustain shared interests via communication systems and other ways not necessitating continuous face-to-face contact" (McCarthy, 1972, p. 40).

Fifth, repetitive interaction over time is an essential requisite for network formation; this requisite implies the need for continuity in roles which are central to the main interest of the network. It does not imply occupying a particular position in a given organization. However, having an organizational affiliation is instrumental for network participation.

And, sixth, the scope of third cultures may encompass people from two or more societies. Participants from two societies form a bi-national third culture; if members come from a cluster of more than two societies, they generate multi-national third cultures; and when people from all over the world are involved, they create worldwide third cultures.

b. <u>The third cultures of science</u>. Restivo and Vanderpool (1974, p. 461), building upon a formulation previously presented by Useem (1971, p. 14), define the third cultures of science as "the cultural

(including intrascientific) patterns created, shared, and learned by scientists of different societies who are in the process of relating their societies (or sections thereof) to each other." These authors point out that at least three factors determine the emergence of third cultures out of the transactions among scientists of different societies: i) the existence of adequate media of communication; ii) the sharing of views about "reality" and scientific goals; and iii) compatibility in the definition of scientific activities in different societies.

Ideally, third cultural networks of science will open avenues for increased communication and cooperation among segments of different societies, which hopefully may facilitate the creation of new appropriate views and opportunities for modernization and social progress. These new scientific communities may include mutually influencing linkage systems between newcomers to S&T endeavors and the centers of world science. Through these personalized connections flow ideas, skills, research techniques, and present and future images about humankind.

c. Types of linkages. Based on their studies in South East Asian countries, the Useems, Othman, and McCarthy (1980, pp. 38-41) have differentiated four types of links in third cultural networks of science (extensive, intensive, nascent, and latent) and have elaborated profiles for scientists who predominantly have each type of linkage. They are described, in the authors' words, in the following paragraphs:

> Extensive transnational networks. Scientists with extensive third cultural networks are persons who have commanding knowledge of their field and are considered to

be leading representatives within...the worldwide scientific community. Their daily conversations touch upon the latest problems and issues of interest in their specialty and, to some degree, in science and technology in general. They are nationally and often internationally recognized scientists, have established reputations in their specialization but also understanding of the problems in adjacent fields. They attend foreign-held international conferences, teach as exchange scholars or serve as guest speakers at a series of institutions abroad. Typically they are members and fellows of foreign scientific societies and have given papers both locally and abroad. Their continuous communicaton with foreign colleagues is the primary source of information for keeping up to date. They often exchange reprints and preprints with their "significant others" abroad in the same specialty. Scientists with extensive international ties know what is being worked on in their field and who is working on those projects.

Within their countries, they can be described as influentials or brokers--those persons who are likely to influence the direction of scientific research by controlling appointments, promotions, and the distribution of special subsidies and awards; they can secure admission for their best students in foreign universities, and are instrumental in establishing arrangements between their home university and a foreign foundation, agency, or institution. They are "insiders" among highly mobile people who know about each other before meeting, and hence are aware of the norms of moving swiftly into "shop talk."

Those with extensive networks interact with many others, but only in narrowly defined segments of the total person. The personal dimenson is not so much ignored as respected and used for making realistic judgements concerning the "business" at hand.

Intensive transnational networks. Intensive networks are both professional and highly personalized. They occur with one or a few scientists in foreign countries, and encompass more of the totality of the individuals involved. They are multi-bounded relationships, often involve parts of the "private selves," and often include family members. Many have a long history of being together in various places and times--as fellow graduate students, as first teacher-students and subsequently colleagues in a study, as collaborators in a major research project, and as intimate friends who meet together while attending international conferences.

Slim transnational networks. Slim networks between our sample scientists and foreign counterparts refer to more tenuous and often more protean relationshps than is true of the extensive or intensive networks. Some are nascent ties of young scientists with former teachers and fellow graduate students which have not yet had time or opportunity to develop. Some are those being developed at mid-career as individuals enter new fields of research or administrative roles, or have more opportunities to attend international conferences. Others are fading extensive or intensive networks as the participants shift away from research

interests which were previously shared, or as changes in the allocation of funding have contracted opportunities to carry out research or directly interact with foreign colleagues. Other slim relationships might be classified as latent, and could be renewed should priorities of support change once more or political differences betwen the nations of their citizenship take a different turn.

No networks. The scientists with no interpersonal, third-cultural networks include: some who have the potential of establishing personalized ties abroad and hope to do so in the future, but have not done so up to now because of their newness to their academic and professional roles; others who have entered into full-time administrative roles, or extra-scholarly pursuits in private and public life and have curtailed their research and active communicaton with scientists in foreign countries; a few who for ideological-nationalistic reasons prefer to minimize further contacts with foreign scientists, institutions, and foundations; and some whose foreign counterparts have retired, died, or moved into other research emphases.

F. The study setting.

This context includes overviews about four settings: 1) CIAT as a research and training organization; 2) the food problem in Latin America, to the solutions of which agricultural organizations and researchers are expected to contribute; 3) four specific crops as foci of their research; and 4) the trainees' home organizations.

1. CIAT as a research and training organization. The Centro Internacional de Agricultura Tropical (CIAT) is one of the organizations supported by the Consultative Group on International Agricultural Research (CGIAR) with the mission of helping nations develop their capabilities to increase agricultural production (see Section c in the Review of Literature, pp. 30-32).

a. Origin. CIAT grew out of an initiative by the Ford and Rockefeller Foundations, which commissioned Dr. Lowell S. Hardin (Ford Foundation) and Dr. Lewis M. Roberts (Rockefeller Foundation) to study the problems of agricultural productivity in the tropics of Latin

America, and to recommend a course of action. As a result of the study, Hardin and Roberts submitted in October, 1966, the document "A Proposal for Creating an International Institute for Agriculture Research and Training to Serve the Lowland Tropical Regions of the Americas" (CIAT, 1981).

On the 12th of May, 1967 an agreement to establish the center in Colombia was signed between the Colombian government and the Rockefeller Foundation. The first meeting of the Board of Trustees was held on October 17, 1967. In 1968 CIAT's headquarters moved from Bogotá, Colombia's capital city, to a 522 hectare dairy farm provided by the Colombian government without cost to CIAT. This farm, located between the cities of Cali and Palmira in the Cauca Valley, has been the main station for CIAT's operations. Research and training activities started there in 1969 (CIAT, 1981).

b. Objectives. The center began its activities with a broad focus on agricultural development, operationalized in terms of the priorities identified by Hardin and Roberts. Two divisions for research were established at the beginning: animal sciences and plant sciences. Under the Animal Sciences division two programs were formed, one with emphasis on rumiants and the other on swine production. Plant Sciences had three programs: the Cereals Program, which included rice, maize and sorghum; the Grain Legumes Program, with soybeans and field beans; and the Tropical Roots Program, with cassava, sweet potatoes, and yams. Parallel to the two research divisions, a strong Training and Communication Program was created.

Through the years a continuous refinement of philosophies, scope, strategies, and operations has characterized CIAT's evolution.

At present its statement of objectives is:

> To generate and deliver, in collaboration with national institutions, improved technology which will contribute to increased production, productivity, and quality of specific basic food commodities in the tropics--principally countries of Latin America and the Caribbean--thereby enabling producers and consumers, especially those with limited resources, to increase their purchasing power and improve their nutrition (CIAT, 1981, p.39).

This statement emphasizes that: a) the product of CIAT's work is improved technology to increase production, productivity, and quality of selected basic foods; b) CIAT's activities are collaborative in nature, the main collaborator being the national institutes; c) the tropics of Latin America and the Caribbean constitute its geographic scope; and d) limited resource producers and consumers are expected to be the principal beneficiaries of CIAT's work.

c. Research approach. Current CIAT research work is focused on four commodities: rice, common beans, cassava, and tropical pastures. Although research work on these commodities was carried out from the beginning of CIAT's operations, a sharp focus on them arose at different points in time. Emphasis on rice and cassava started in 1969. Formation of a program focused only on common beans dates from 1973. The present concentration on tropical pastures has resulted from successive approximations to a broad set of problems which initially encompassed the areas of animal health, animal management, and cattle production systems. This initial approach operated under the name Beef Production Systems Program for six years. Between 1975 and 1977 these activities were concentrated on soils problems which are

characteristic of the acid infertile savannas of Latin America. The name at that time was changed to Beef Production Program. From 1978 to the present, the focus has been geared to obtaining low-cost, grass-legume associations fo the acid soil savannas. To reflect this focus a new name was adopted in 1979: Tropical Pastures Program (CIAT, 1981).

Underlying CIAT's focus on a few crops is the assumption that such strategy will enable the center to make not only better additive contributions to generation of technology, but to serve catalytic functions which may help overcome institutional constraints imposed on agricultural research in the region. The rationale is that: a) concentration of efforts in problem solving, production oriented, interdisciplinary research will result in more rapid progress in the development of appropriate agricultural technologies for the region; b) more effective research will stimulate governments to better recognize the value of agricultural research; and c) increased value for agricultural research will result in higher levels of funding for national research organizations as well as higher social recognition of the work of agricultural researchers (CIAT, 1981, pp. 24-26).

d. Training activities. Higher investments in agricultural research would produce increased need for more and better trained researchers. Universities are the major contributors to increasing the number of highly educated personnel. International centers, within their specific foci, can also make a contribution in this respect. Training activities have been an integral component of CIAT's philosophy

and strategies since its initial conception by Hardin and Roberts. Training orientations and emphases have followed the development trends of the center. At present training is the largest of CIAT's outreach services. Its major goal is "strengthening the capacity of national institutions to carry out, cooperatively as well as independently, their key technology adaptation and transfer functions" (CIAT, 1979, p. 7). In the implementation of this goal training activities have focused on building "critical masses" of professionals trained in research on CIAT's commodities, who are able to effectively conduct multidisciplinary, team work in relevant organizations of selected countries; the expectation has been that these researchers will establish collaborative links within and among national organizations, and between such organizations and CIAT (CIAT, 1981).

2. The food problem in Latin America. An overview of some aspects of this highly complex problem is presented as an additional contextual reference. Three components of that problem which are related to agricultural research are: a) the nutrition problem; b) the production gap; and c) the heterogeneity of Latin American agriculture as a socio-economic activity.

a. The nutrition problem. Caloric and proteinic deficits are present in large segments of the population of Latin America. Figures for fifteen countries show that where deficits are less severe at least one third of the population consumes diets below minimum requirements. In other countries of the region the problem

problem affects over two thirds of the population (Table 4). Nutritional deficiencies are directly tied to low income or lack of it. Improved technology by itself is not a solution of the problem of nutrition. However, technology can have indirect effects on the diet of low income population through its effects on prices and qualities of food products (CIAT, 1981).

b. The production gap. Looking at aggregate figures for the region as a whole, food production has grown consistently with food demand in Latin America, at a rate of 3.6% per annum since 1960. However, individual figures reveal that this has not been the case for sixteen of twenty-one countries (Figure 2). All Latin American countries located within the tropics are net importers of food staples. If current rates of growth in production are projected to 1990, food deficits in all tropical countries are expected to increase by 50%, except for Brazil and Paraguay (IFPRI, 1977; CIAT, 1981).

c. Heterogeneity of Latin American agriculture. The heterogeneity of agriculture in Latin America may be realized by considering two interrelated contradictions: i) while there is a high pressure on agricultural land currently under the plow, such land represents only somewhere between 18 and 35 percent of Latin America's potential land resources for agriculture (CIAT, 1981, p. 2); and ii) while small farms represent a high proportion of agricultural enterprises, and while small farmers are the most efficient producers in combined utilization of land, labor, and capital (Berry, 1979), their contribution to total agricultural output is very limited. These contradictions are tied to the facts that: i) the cost of production

Table 4. Estimated percentages of the population consuming inadequate amounts of calories in various Latin American countries (1973).*

Country	Below Minimum Caloric Levels %	Below 90% of Recommended Caloric Levels %
Honduras	60	50
Ecuador	70	61
El Salvador	72	61
Colombia	61	46
Dominican Republic	58	44
Guatemala	69	48
Brazil	45	31
Mexico	34	22
Jamaica	30	21
Peru	53	41
Costa Rica	34	20
Panama	51	38
Chile	33	10
Uruguay	33	20
Venezuela	56	47

* Data are available from the Food Balance Sheets of FAO on mean caloric consumption, and FAO/WHO have made estimates of caloric requirements. The distribution of the population by caloric consumption utilizes income distribution data and the functional relationship between calorie consumption and income.

Source: S. Reutlinger and H. Alderman, The Prevalence of Calorie Deficient Diets in Developing Countries, World Bank Staff Working Paper No. 374, Washington, D.C., March 1980, pp. 27 and 28.

Taken from: CIAT, 1981, Appendix 3.

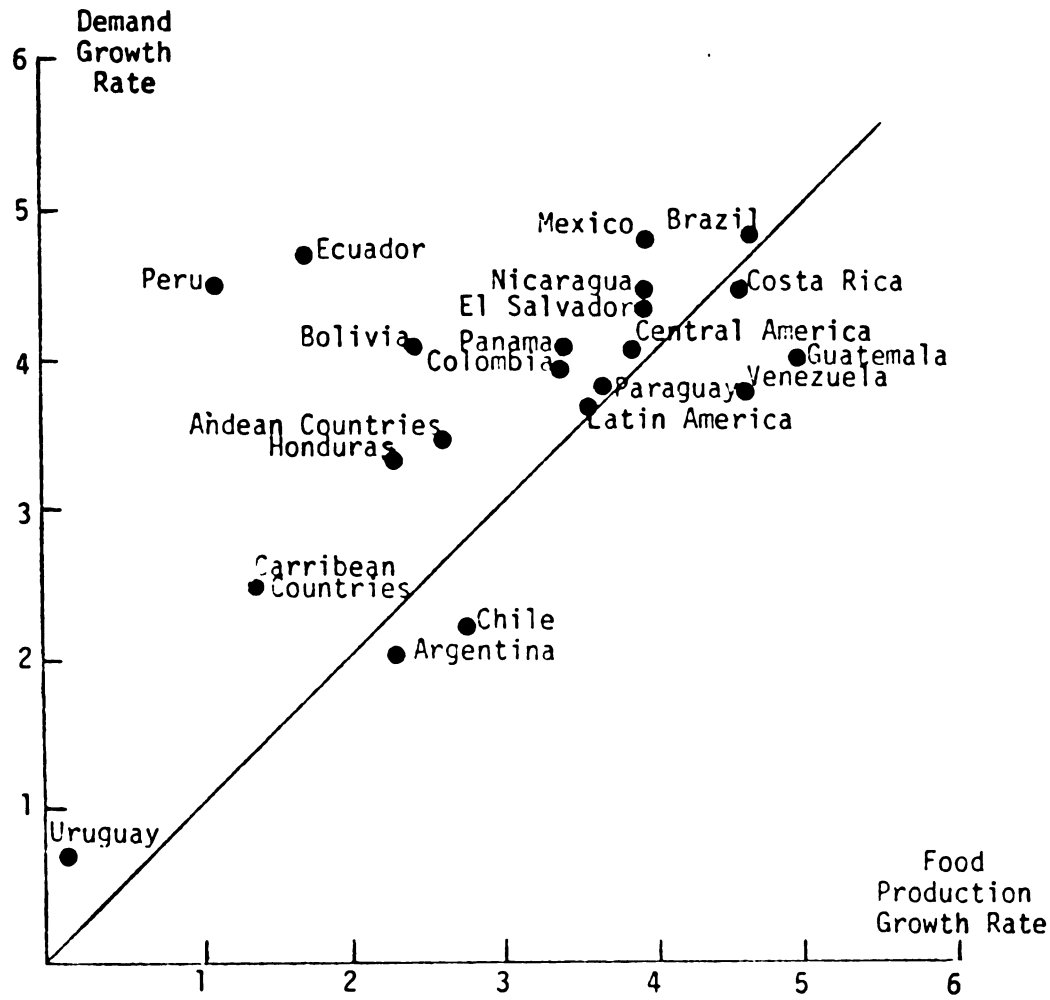

Figure 2. Growth rates of demand and production of food in the Latin American countries (1966-77).

Source: CIAT, 1981, Appendix 10.

for infrastructure and soil correction appear to be presently too high to support a more rapid expansion of land use at the agricultural frontier; and ii) small farmers control only a minor portion of land and capital resources. The picture is complicated by the high variability in ecosystems, the increasingly young age profile of the population, and a heavy migration from rural areas to cities where unemployment is already a grave problem. These complexities of Latin American agriculture impinge on reseachers' work performance. They are expected to generate appropriate technology for both the commercial and the subsistence sectors. Technology for the commercial sector usually is capital intensive. On the contrary, small farmers require labor-intensive technologies.

3. Crops as contextual setting. CIAT's four commodity programs constitute another contextual setting for this dissertation. In terms of research each commodity has characteristics of its own, linked to production ecosystems and cultural and socio-economic traits of those who produce them, as well as to previous research work conducted within and outside the region in those commodities. Following are some points of reference.

a. Rice. The importance of rice as a basic food crop in Latin America has been increased over the past 15 years, as a rapidly urbanizing population has shifted from other staples to rice as a principal calorie source. In some countries of the region, this tendency is related to an apparent decline in per capita direct consumption of maize (CIAT, 1981).

The increase in consumption has been largely satisfied within the region, with imports remaining around 150,000 tons per year, and

intra-regional trade increasing to 360,000 tons per year, 36% larger than the level in 1963-65. About two thirds of the production growth has come from an increase in area (mainly in the upland sector) and the remainder from increases in yields (mainly in the irrigated sector) (CIAT, 1981).

There is a large diversity in the ways in which rice is produced in Latin America, varying between intensive irrigated systems to extensive or subsistence upland systems at the frontier. The main ecological factor determining a production system is the rainfall patterns and possibilities of improved water management. In terms of output, rice is predominantly a larger farm crop, but it is practiced by many operators of small holdings; farms of five hectares or less in Latin America represent about one third of the total number of production units under non-irrigated conditions, and about 13% of those operated under irrigation (Scobie and Posada, 1977).

Rice is perhaps the commodity with a longer research tradition, building upon a knowledge base fostered by IRRI and other research centers in Asia as well as in other parts of the world. Compared to the other three commodities emphasized in CIAT training activities, rice enjoys acceptable, developed research programs in national organizations. Ten countries are classified for this thesis within a group with more facilities to carry out rice research: Argentina, Brazil, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Peru, and the Dominican Republic.

b. Bean. The common bean is the most important grain legume for direct human consumption in the world. It is a traditional food

in Latin America, providing the cheapest source of protein and a relatively inexpensive calorie source (CIAT, 1981).

Bean production in Latin America is characterized by low profitability and high risks, which result from the interaction between biophysic, political, and socio-economic factors. For example, some common traits of bean production are: high variation in yields in relation to climatic variations, high susceptibility to the attack of insects and pathogens, high price fluctuations, low economic incentives to producers, and production carried out mainly by poor farmers on poor lands and with poor water supply.

There is a wide range of cropping systems in Latin America for bean production, going from bush mono-culture to climbing beans in association with maize. Bean production has been stagnant, with yields generally declining. A slight expansion in area has occurred, but it has only compensated for yield declines. A large gap exists between experimental and farm productivity, experimental yields ranging between three and five tons/hectare, when farm yields average only 0.6 tons/hectare (CIAT, 1981).

The complex of factors associated with the crop make it difficult to generate appropriate technologies for bean production. Staff members of CIAT consider that all of the major environmental and biological constraints to increased production are researchable (CIAT, 1981, p. 71). National research programs have existed in Latin America for years, but progress in technology generation has been limited. The programs of Mexico and Colombia have made considerable advances. Other countries of the region which are classified for the purpose of this dissertation as having facilities to do bean research are Argentina, Brazil, Chile, Guatemala, and Peru.

c. Cassava. At present this is a basic source of calories for large segments of the rural population in 26 tropical countries of the world. For Latin America it is very popular in Brazil, Colombia, and Paraguay. Consumption in urban areas is more limited because of its high perishability and high marketing margins as a fresh product. However, an important potential is attributed to cassava for human consumption as well as for industrial utilization, such as production of a wheat flour substitute, feed concentrates, ethanol, and starch. Fulfillment of such potential is dependent on more agricultural research, and on development of infrastructure capacities for processing and marketing. Cassava strengths reside in its remarkable efficiency in carbohydrate production, adaptation to soil and water stress, indeterminate harvest period, high yields per unit of land and labor, and compatibility in association with a variety of crops (CIAT, 1981).

In Latin America, cassava crops can be found under a wide range of ecological conditions, from the lowland tropics with high temperatures to the cool highlands of the Andean cordillera. Production modes range from the slash-and-burn system of the Amazon jungle, to planting cassava as an introductory crop in pasture establishment, and to small farm multi-crop systems, frequently in association with a legume or maize. It has comparative advantages in areas where there are major constraints on the growth of other crops.

Systematic research on cassava does not have a long historical tradition. National research programs in Latin America are very new, most of them in operation for less than ten years and still in the formative stage. Nevertheless, experimental yields have considerably

increased. CIAT has had experimental yields up to 80 tons/hectare which in comparison with average farm yields of 10 tons/hectare suggests high potential for raising farm productivity (CIAT, 1981).

d. Tropical pastures. In the preceding paragraphs, three single crops--rice, beans, and cassava--were presented as contextual frameworks for training. The case of tropical pastures is different in two respects.

First, tropical pastures have not been a continuous focus during the period of training analyzed here. They constitute a more recent stage in a research area which started by working on beef production, and since then has been making successive redefinitions of its philosophy, aims, approaches, and priorities.

And second, what is called here "tropical pastures" is not a set of already defined species. It is, rather, a research focus aimed at developing low-cost/low-input technology for the production of pastures in extensive tropical regions of Latin America, which are characterized by acid, infertile soil conditions. The rationale behind this selective focus in tropical pastures is that such technology would provide economically and ecologically sound alternatives for the utilization of those regions. Food producers and consumers would be the main beneficiaries. Improved production of pastures would result in increased animal production and productivity. These developments would allow the agricultural frontier to expand in the tropics of America, and to release more fertile lands, today utilized in animal production, for the production of other crops.

CIAT estimates that the tropical and subtropical areas of America have nearly a billion hectares of underutilized savannas and

forests, 75 of which are occupied by acid and infertile soils. These areas have great agricultural potential since they have abundant solar radiation with adequate rainfall and favorable temperatures for extended growing seasons. Topography and soil physical conditions are also generally favorable. The current average stocking rate in the acid savannas is 0.12 animal/hectare. This can potentially be increased more than tenfold. In addition, beef production per animal/year could be more than doubled. However, the available technology is not profitable in these areas. Furthermore, another source of constraints in such regions is infrastructure; but beef produced extensively does not require a well developed infrastructure for inputs or marketing outputs (CIAT, 1981, pp. 93-102).

Similar to the case of cassava, there is no long research tradition in Latin America in tropical pastures. CIAT considers the main constraint to expanding research collaboration in this subject as the absence, in most countries, of strong pasture research programs working in areas with acid infertile soils. Existing programs tend to concentrate on more fertile soils and areas where animal production has expanded in the past, and where more of the cattle population is still located (CIAT, 1981, p. 111). Only four countries of the region were classified for the purpose of this thesis as enjoying research facilities for tropical pastures: Argentina, Brazil, Colombia, and Venezuela.

4. The trainees' home organizations. A growing number of organizations in Latin America send members of their professional staff to CIAT to advance their training in agricultural research. The main user of these training opportunities is the national agricultural

research institute. In addition, a diversity of governmental and private organizations are showing interest in fostering the research competencies of their personnel. Included among them are agricultural extension agencies, banks and financial organizations, agricultural universities, associations and federations of crop producers, and a number of private agro-businesses related to production and marketing of inputs such as seeds, pesticides, and fertilizers.

A large number of organizations (182 private and public agencies) scattered acrosss 26 Latin American and Caribbean countries have utilized CIAT's opportunities for preparing research personnel. This figure suggests a growing interest in the region for establishing agricultural research capabilities in relationship to the four commodities of CIAT's mandate. However, the number of persons trained is not evenly distributed in those agencies. Twenty-one out of the 182 sponsoring organizations account for half of the personnel trained in research during the period 1969-79. This concentration reflects CIAT's policy of building "critical masses" of researchers in selected organizations, and it may be also interpreted in the sense that a small cluster of Latin American organizations have implemented more assertive policies of human resource development for S&T in the fields of agriculture (Table 5).

Table 5. Former CIAT research trainees, distributed by number of trainees per sponsor organization (N = 783).*

Number of trainees per organization	Organizations Number	%	Trainees Number	%
1 - 3	130	71.4	204	26.0
4 - 8	31	17.1	172	22.0
9 - 23	15	8.2	206	26.3
24 - 48	6	3.3	201	25.7
	182	100.0	783	100.0

* This distribution indicates the organizational origins of trainees, and not their present locations.

CHAPTER III

STUDY DESIGN

This chapter describes how data reported in this thesis were collected and analyzed. The study population is defined and delineated by size, training content, length of training, facilities to do research at sponsor organizations, and a set of characteristics of its members (age, gender, marital status, education, and country of origin). The rest of the chapter presents details about instruments and procedures applied in gathering data for the analyses of human resource inventories and networks of researchers.

A. Strategy.

The general strategy for data collection consisted of three activities: 1) to gather all relevant data available at CIAT on the study population; 2) to collect data for the question of inventories of human resources through a mail census to all Latin American organizations which sponsored trainees at CIAT during the period 1969-1979; and 3) to obtain data for network analysis by means of a mail questionnaire sent to all members of the study population who had done research after training and whose addresses were known at the time of the survey.

B. Delineating the population.

1. Definition. The study population is defined as composed of all former research trainees from Latin America who completed their training between December 31, 1969, and December 31, 1979, in any of the four CIAT commodity programs, and for whom there were records in the CIAT training files.

2. Data gathering. Data for delineating the population were obtained from both the files and staff of CIAT. The total data collected from these two sources made it possible to: a) determine the size of the population; b) describe its distribution by the three independent variables of interest; and c) characterize it in relationship to age, gender, marital status, formal education, country of origin, and year of training completion. In addition, organizational reports obtained during this phase of the study provided the basic materials for writing a description of the training setting.

3. Population size. The determination of the population size consists of identifying and counting those professionals who fit the population definition. Two types of persons are excluded: a) all students whose names are in the files because they were financially supported by CIAT, but whose actual training was carried out at educational organizations other than CIAT; and b) all postdoctoral fellows because they differ from the study population in status and activity at CIAT. The size of the population so determined consists of 783 Latin American agriculturists. It represents 62.2% of the total number of 1259 persons who had completed their training at CIAT between December 31, 1969, and December 31, 1979.

4. Strata for independent variables. The following strata were constructed in order to classify the population according to training content, length of training, and facilites to do research in the fields of training at sponsor organizations.

a. Strata for training content were readily available in the records. They constitute the four CIAT commodity programs: rice, beans, tropical pastures, and cassava.

b. Strata for length of training were constructed on the basis of the following patterns which have emerged over time in the CIAT training programs: i) In general, periods of training up to two months correspond to structured short intensive courses, mainly carried out within classrooms, and usually focused on a commodity, e.g., rice, or a field of research within a commodity, e.g., multiplication of cassava germ plasm by means of meristems. ii) Training periods from two months to six months usually are less structured than short courses, take place almost totally at labs, greenhouses, and reserch fields, and are designed for gaining specialization in a discipline or field of research within a commodity, e.g., cassava phytopathology, rice plant breeding. iii) Periods longer than six months commonly involve the pursuit of a research project under the guidance and supervision of a researcher of the staff of CIAT; and sometimes the projects are connected with fieldwork for M.Sc. and PhD theses.

c. Strata for support facilities to do research at home organizations were more difficult to construct and apply to this population. Several possibilities were examined for macro-data, for instance, investment in agricultural research in each Latin American

country, or resources available for agricultural research at Latin American organizations. The data found were insufficient to construct a comprehensive set of strata inclusive enough to classify all members of this population. In addition, those data were not directly related to the commodities around which research training is organized at CIAT. Hence, the decision was made to try using the judgement of competent researchers who know the research facilities available at agricultural organizations in Latin America. Two researchers from the staff of each CIAT commodity program were asked to classify all countries of the region according to two categories: those having more facilities to do research in the fields in which CIAT has had training programs, and those with less facilities. These two categories are referred to below as the "more" and the "less" facilities. The category "less" does not mean inadequate facilities. Experts who were asked to make appraisals were selected with the criterion that they had been personally involved in CIAT international cooperation activities, so they would have first-hand knowledge about the research facilities available at national organizations in their specialized fields.

There was little disagreement amongst the two separate sets of appraisals about the classification. When it appeared, disagreement was resolved by contacting other experts and discussing with them the issues until an acceptable level of consensus was reached. Experts did not judge other fields of research but only their own. For example, cassava researchers classified the countries according to their judgement on the facilities available to carry out cassava research, but did not judge research facilities for other commodities.

The resultant classification is in Table 6. Twelve countries of the region were classified as having "more" facilities for at least one of the four CIAT reseach commodities. These 12 countries are: Brazil and Colombia, which have "more" research facilities for all four commodities; Argentina and Mexico, for three commodities; Guatemala, Peru, and the Dominican Republic, for two commodities; and for only one commodity, Cuba, Costa Rica, Chile, Ecuador, and Venezuela. All other Latin American countries were classified as having "less" facilities to carry out research in the fields in which CIAT offers research training.

5. Population distribution in conjunction with each of the independent variables (Table 7). Out of the 783 research trainees, 173 (22.1%) carried out their training in rice, 245 (31.29%) in beans, 172 (21.97%) in tropical pastures, and 193 (24.64%) in cassava. Although differences in the proportions of trainees who were exposed to each training content are not large, a slight concentration is noticeable in the number of persons in beans research. Rice and tropical pastures training takes place approximately in the same proportions, and the proportion of training in cassava was in between the other three contents.

With respect to length of training, almost half of the population (49.43%) had a short period of training of two months of less, about one third (32.43%) had an intermediate period of more than two up to six months, and slightly more than one sixth (18.14%) had a training period longer than six months (Table 8).

Table 6. Classification of Latin American countries by availability of facilities to do research in areas in which training was carried out at CIAT.

	Research facilities							
	Rice		Beans		T. pastures		Cassava	
Country	More	Less	More	Less	More	Less	More	Less
Antigua		X		X		X		X
Argentina	X		X		X			X
Belize		X		X		X		X
Bolivia		X		X		X		X
Brazil	X		X		X		X	
Colombia	X		X		X		X	
Costa Rica	X			X		X		X
Cuba		X		X		X	X	
Chile		X	X			X		X
Ecuador	X			X		X		X
El Salvador		X		X		X		X
Guatemala	X		X			X		X
Guiana		X		X		X		X
Haiti		X		X		X		X
Honduras		X		X		X		X
Jamaica		X		X		X		X
Mexico	X		X			X	X	
Nicaragua		X		X		X		X
Panama		X		X		X		X
Paraguay		X		X		X		X
Peru	X		X			X		X
Puerto Rico		X		X		X		X
Dominican Republic	X			X		X	X	
Trinidad		X		X		X		X
Uruguay		X		X		X		X
Venezuela		X		X	X			X

Table 7. Distribution of the study population by training content, length of training, and facilities to do research at home organizations.

Independent variable	N	%
Training content	783	100.00
Rice	172	22.10
Beans	245	31.29
Tropical Pastures	172	21.97
Cassava	193	24.64
Length of training	783	100.00
Up to two months	387	49.42
More than two months, up to six months	254	32.44
More than six months	142	18.14
Facilities to do research	783	100.00
"More" facilities	514	65.65
"Less" facilities	269	34.35

Table 8. Number of research trainees from Latin America, distributed by content and length of training.

Content	Length of Training: 2 months N_1	%	2<m≤6 N_2	%	>6 months N_3	%	TOTAL N	%
Rice	73	9.32	81	10.34	19	2.43	173	22.09
Beans	135	17.24	84	10.73	26	3.32	245	31.29
Pastures	36	4.60	67	8.56	69	8.81	172	21.97
Cassava	143	18.26	22	2.81	28	3.58	193	24.65
TOTAL	387	49.42	254	32.44	142	18.14	783	100.00

Table 9. Latin American research trainees distributed by training content and facilities to do research at home organizations.

Content	Facilities: More N	%	Less N	%	TOTAL N	%	Ratio More/Less
Rice	133	16.99	40	5.11	173	22.10	3.3
Beans	150	19.16	95	12.13	245	31.29	1.6
Pastures	87	11.11	85	10.86	172	21.97	1.0
Cassava	144	18.39	49	6.25	193	24.64	2.9
TOTAL	514	65.65	269	34.35	783	100.00	1.9

As for facilities to do research at home organizations, the proportions were two to one: about two thirds (65.65%) of the population came from countries classified as having more research facilities in the research area in which training was carried out, and approximately one third (34.35%) came from countries classified as having less facilities (Table 9).

Tables 8 and 9 show how proportions for length of training and research facilities distribute in relationship to training content. Training in rice or cassava is more concentrated in those countries classified as having more facilities to do research: the proportion more/less, as indicated in Table 9, is three to one in rice and cassava, while it is two to one for the whole population. For the other two commodities, in contrast, the proportions more/less are below the general proportion, two to one, for the whole population, being almost even (one to one) for tropical pastures. As for length of training, cassava and beans programs have concentrated in short training periods, rice programs have focused on short and intermediate training with a slight tendency toward the intermediate ones, and tropical pastures have emphasized intermediate and longer periods with a slight tendency toward longer training (Table 8).

6. Profile of the study population in terms of age, gender, marital status, education, and country of origin. Most of the research trainees are relatively young males, married, and have an education at the B.S. level (Table 10). People under 34 years of age represent sixty percent of the population. That nine out of ten are males reflects the historical fact that females have been entering agricultural research careers in Latin America only recently. With

Table 10. Distributions of the study population in terms of age, gender, marital status, and education.

Characteristic	N	%	Cumulative N	Cumulative %
Age in years				
Less than 30	182	23.24	182	23.24
30 - 34	290	37.04	472	60.28
35 - 39	196	25.03	668	85.31
40 - 44	69	8.81	737	94.12
More than 44	46	5.88	783	100.00
Gender				
Female	52	6.64	52	6.64
Male	731	93.36	783	100.00
Marital Status				
Single	283	36.14	283	36.14
Married	500	63.86	783	100.00
Education				
Less than B.S.	25	3.19	25	3.19
B.S. or equivalent	678	86.59	703	89.78
M.S. or equivalent	74	9.45	777	99.23
Ph.D. or equivalent	6	0.77	783	100.00

respect to marital status, the proportion of married to single people is almost two to one. A few former CIAT trainees (3.19 percent) do not have an education at the B.S. level or the equivalent; most of them come from countries where agricultural education at the university level has been established only recently. But the bulk of the study population (86.59 percent) has formal education at the B.S. level. One out of ten has studied beyond the B.S. level; most of these held a Master's degree at the time of training or were at CIAT carrying out fieldwork for their theses; some of the persons classified at the PhD level had not graduated by the time of their training at CIAT, but were in the last stages of their doctoral work.

The ages and educational levels predominant in this population suggest that most of its members were entering research careers when they went to CIAT for their training; perhaps many were in their first job; and a high proportion of former CIAT research trainees probably occupied low, or at most, intermediate positions in their organizations before training.

With reference to country of origin, a high proportion of the study population came from two countries, Brazil and Colombia. In fact, Brazil sponsored nearly one fourth and Colombia one fifth of former CIAT research trainees. Seven countries sponsored percentages between four and six percent: Ecuador, Mexico, Peru, Guatemala, Venezuela, Honduras and the Dominican Republic; these seven countries altogether account for 36.14 percent of the population.

There are seven other countries, each one sponsoring between one and four percent of former CIAT research trainees: Costa Rica, Bolivia, Cuba, El Salvador, Chile, Panama, and Argentina; they

supported almost 17 percent of the population. The rest of the Latin American countries (ten out of 26) account, in total for less than five percent of former CIAT reseach trainees (Table 11).

The concentration of CIAT research training in Brazil and Colombia during the past decade may be associated to country science policies and easy access to CIAT. Brazil gives high priority to the development of indigenous scientific capabilities for its productive sectors. Since the 1960's Colombia has been actively engaged in preparing human resources for agricultural research. The circumstance that Colombia is the host country for CIAT activities has facilitated the access of Colombian agriculturists to CIAT's training programs.

Other factors which might explain the uneven proportions presented in Table 11 are: lack of awareness in some countries about the research training opportunities available at CIAT; less relevance of CIAT's work for non-tropical countries, e.g., Argentina and Uruguay; preference of science policy makers and professionals of some countries for degree training or for the educational facilities offered by more developed countries; and low or no priority assigned to agricultural research in other countries.

C. Inventories of researchers: Data collection and analysis.

A population survey was preferred over a probabilistic sample. Two considerations made advisable this decision. First, the nature of the research question (inventory formation) seemed to be more amenable for a census, particularly in relationship to data analysis. And second, criteria for designing an adequate sampling schedule for this population were not available. For instance, the author was unaware

Table 11. Research trainees from Latin America distributed by country.

Country	N	%	Cumulative N	Cumulative %
Brazil	185	23.63	185	23.63
Colombia	147	18.77	332	42.40
Ecuador	52	6.64	384	49.04
México	47	6.00	431	55.04
Perú	44	5.62	475	60.66
Guatemala	36	4.60	511	65.26
Venezuela	36	4.60	547	69.86
Honduras	35	4.47	582	74.33
Dominican Republic	33	4.21	615	78.54
Costa Rica	27	3.45	642	81.99
Bolivia	27	3.45	669	85.54
Cuba	21	2.68	690	88.12
El Salvador	19	2.43	709	90.55
Chile	16	2.04	725	92.59
Panamá	13	1.66	738	94.25
Argentina	10	1.28	748	95.53
Nicaragua	7	0.89	755	96.42
Guiana	7	0.89	762	97.31
Belize	6	0.77	768	98.08
Haití	5	0.64	773	98.72
Paraguay	4	0.51	777	99.23
Uruguay	2	0.25	779	99.48
Puerto Rico	1	0.13	780	99.61
Antigua	1	0.13	781	99.74
Jamaica	1	0.13	782	99.87
Trinidad	1	0.13	783	100.00

of previous assessments of several factors likely relevant to formation of inventories of human resources for agricultural research in Latin America, e.g., country of origin, organizational affiliation, date of training, among others.

1. Objectives. The main objective of the census is to gather quantitative data about formation of human resource inventories for agricultural research with basis on the personnel trained at CIAT. In addition, the census provides an opportunity to fulfill two instrumental needs. First, to legitimize with the national sponsor organizations, the study and the investigator who carried it out. Second, to generate a mailing list required for the subsequent stage of the study.

2. Instruments. The instrument for the main objective of the census consists of a check list and its instructions. The check list is designed in a matrix format (See Appendix B). It has at the top the name and year of training completion of a particular professional. Years from 1969 to 1979 are the headings of the matrix columns. Information requested for each particular professional during each year after training is presented in short sentences in the matrix rows. Meanings assigned to such sentences are explained in the instructions.

By means of these census instruments the investigator asks directors of organizations to provide the requested data by checking inside the cells of the matrix when the answer to each particular question is positive, and not checking when it is negative. So, answers are nominal in the form "yes," "no," with each answer representing one year. Census instructions are presented in a letter format.

Instructions ask for responses to three types of questions with respect to after-training performance of the person whose name and year of training completion is at the top of each matrix check list: a) whether or not that professional worked for the sponsor organization after training, in any kind of activity (row 1 of the matrix check list); b) whether or not that professional did research after training in rice, beans, tropical pastures, or cassava (rows 2-5); and c) whether or not that professional worked after training doing research on species other than the ones mentioned in literal b, or performing research related roles, such as instructor of other researchers, research administrator, or research consultant (row 6).

Below the matrix check list space is provided for comments or for reporting lack of information about that professional. For building the mailing list directors are asked to write the present address of the professional on the back of the check list.

An example showing how to fill out the census instrument is presented in the instructions. A request is also made for completing the appropriate forms in the case that a professional did not return to the sponsor organization or resigned after training, but for whom pertinent information is available.

The instrument for legitimizing the study and the investigator of country-based agricultural organizations in Latin America consists of a personalized letter sent by the Director General of CIAT to directors of all the organizations which sponsored agriculturists for research training at CIAT. Spanish versions of the census instruments are in appendices A and B.

3. Tactics for data collection. Census instruments are pre-tested, revised, and tested again until gaining evidence that they wprk satisfactorily. Such testing is carried out with the cooperation of Colombian organizations which operate in Cali and Palmira in the vicinities of CIAT. Census materials are arranged in sets and put inside mail envelopes, one per organization or sectional when appropriate.

Each set consists of the letter by the Director General of CIAT, the census instructions, a set of check list forms with the names of the professionals whose data were requested, and an addressed return envelope. The possibility of sending pre-paid return envelopes was examined but not implemented in view of the large number of countries included in the census.

During the testing of instruments, it was found advisable to send census materials to a more local level of each organization, because it increased the possibility of getting the specific data requested for each former CIAT trainee. Given that most agricultural research organizations in Latin America have their headquarters office in the country's capital city, and sections in different places of the country, it was decided to send a set of materials to the central office only, mainly in terms of legitimization of the study. Overlapping of names was avoided by first trying to allocate data requests at the local level and then sending the remainder to the central office.

In this way, approximately three hundred sets of materials were sent, corresponding to 182 organizations and their divisions. The sending of the first round of census materials took one and a half

months, from the beginning of July to the middle of August, 1980. A recall was carried out by sending the materials again to those organizations whose answers had not been received. Materials were accompanied by a small card making reference to the original request, the likelihood that it got lost in the mail, and the importance of including such data in the study.

More than ninety percent of the organizations responded. A complementary tactic was to ask people at that time with CIAT about those professionals whose data were missing. Staff members of CIAT as well as participants in training and conferences provided data about after-training performance of former trainees whom they personally knew. Eventually, after a screening procedure, there were complete data for 580 former CIAT trainees, accounting for 74 percent of the study population.

4. Analysis of inventories. The type of analysis of inventories presented in this thesis is analogous to those of accounting techniques. In this sense, this part of the study follows a methodology similar to the approach of the PROTAAL studies (see pp. 39-43). However, the scope of the data is different, and consequently specific definitions for the analytical tools were required.

In each case of PROTAAL studies the focus is a single organization. The formation of inventories of researchers is examined throughout the history of the organization under study. All researchers who entered the organization are included in the analysis, irrespectively of the location of their training. In contrast, in this thesis the focus is on professionals who have been employed by many organizations, and who have carried out some portion of their

research training at a specific place, the Centro Internacional de Agricultura Tropical.

Analytical tools applied for this analysis are: final inventories, initial inventories, annual net balances, trained personnel, migration, efficiency in the formation of inventories, non-returnees, drop-outs, retention and stay of trained personnel, and formation and retention of inventories of research experience. Following are the definitions for each of these analytical tools, as well as the pertinent relationships between them.

a. Effectiveness in inventory formation. Effectiveness of the region in forming inventories of human resources for agricultural research is indicated by the tendencies--increasing, stagnant, decreasing--and absolute values of final inventories (FI). These inventories are calculated by adding (or subtracting, when negative) annual net balances (ANB) to initial inventories (II).

$$FI = II + ANB$$

The number of trained persons available at the beginning of each year forms the initial inventory of the immediately preceding year.

Annual net balances reflect the movements of personnel, e.g., the persons who enter and leave the organizations (or research on their fields of training, on CIAT's commodities, or research in general, according to the perspective under analysis) during a year. They are calculated by subtracting from the personnel trained by CIAT each year (TP) the number of researchers who migrate (M) during that year.

$$ANB = TP - M$$

The trained personnel in a given year is defined as the number of persons who completed their training in research at CIAT up to

December 31 of that year. When trained personnel is higher than migration, annual net balances are positive, and formation of inventories will increase. When trained personnel is equal to migration, net balances are zero, and formation of inventories will be stagnant. And, when trained personnel is lower than migration, balances are negative, and formation of inventories will decline.

b. Efficiency is defined as the percentage which final inventories represent with respect to the cumulative number of trained personnel. It is calculated by the formula:

$$\text{Efficiency} = \frac{\text{Final inventory}}{\text{Cumulative trained personnel}}$$

c. Migration. The component of inventories which diminishes efficiency is migration (M). It is defined as consisting of those persons who, after training, do not return to work for their sponsor organizations (or to do research in their fields of training, on CIAT commodities, or on research in general, according to the perspective analyzed), plus those researchers who leave their organizations (fields of training, etc.). The first group is called here "non-returnees" (NR), and the second category is named "drop-outs" (DO). Migration is computed by the formula:

$$M = NR + DO.$$

d. Retention and stay. Retention (R) designates the number of persons who, after training, have continued working for their sponsor organizations (fields of training, etc.). Retention rates are the percentages which retention absolute values represent with respect to the number of people trained during a given year. (Retention absolute values are the figures occupying the main diagonal in Tables E-1 to E-4, Appendix E.)

This study is focused on the analysis of inventory formation over the period 1969-79, and not on comparing figures for individual years. Therefore, retention is not presented here on a separate annual basis, but cumulatively; figures corresponding to a given year incorporate retention in the preceding years.

Stay indicates the total number of persons who have not migrated up to a given year. Retention figures are not enough for exploring the question, "For how long have professionals stayed in their organizations and done research after training?" Retention is a subset of stay. Its complement is the number of persons who, after training, reentered their organizations (fields of training, etc.), worked there for one or several years, and later dropped out. Consequently, "stay" up to a given year is computed by adding to the figures of retention corresponding to that year, the number of persons of the preceding training years who still have not dropped out. (For the arrangement of data presented in Tables E-1 to E-4, in Appendix E, the procedure of computing "stay" consists of adding the totals of the columns, starting from left to right.)

In addition, the length of the interval after training needs to be considered. It is not equal for all trainees, provided that their training took place at different dates. The size of this interval might influence tendencies of stay in different directions. For instance, a positive correlation might exist between the size of the interval and the magnitude of drop-out, the underlying force being a propensity of people to move with the passing of time. In other words, the higher the size of the interval, the higher the probability

of dropping out. From the other side, a propensity to stay might also exist. It seems reasonable to think that the longer a person has stayed practicing a professional activity or working for a given organization, the more well established that person would become in that activity or organization, and correspondingly the higher would be his/her propensity to remain working on that activity or for that organization. The preceding considerations made advisable not to give a single rate of stay for the whole period analyzed, but to present rates annually, according to the size of the interval between the year of training and 1980.

e. Research experience. Retention and stay are closely related to one variable of much importance in scientific research: experience. In its essence, experience is generated cumulatively by doing. An unrefined indicator of experience is the number of years a person stays doing a given activity. This is an oversimplification because it assumes that every person is devoting 100% of their work time to that activity, and because it also assumes that one year of experience of person A is equivalent to one year of experience of person B, which might not be the case. However, for the purpose of getting a notion about what occurs in this sample with regard to experience formation and retention, this indicator is considered adequate.

The following analysis of formation and retention of research experience is based on five concepts: potential experience (PE), actual experience (ER), and efficiency in experience retention (EER). None of these refer to the number of persons, but to the number of person-years. One person-year is the stay of one person during one year in a given organization or activity.

This analysis of experience is not conducted on an annual basis because the year-by-year figures do not produce more information about trends than what is provided by the series of retention and stay. This is so because the data about number of persons are the same used for preparing those tables; the only difference is that in the analysis of experience such figures are weighted by the size of intervals between training years and 1980.

To summarize the figures about former trainees' performance with respect to the activity of research, the following relationships are applied to findings on non-return to research, drop-out of research, and retention for the activity of research. The difference between efficiency in retention and 100 percent represents the lost efficiency corresponding to the cumulative effects of migration. The difference between efficiency in stay and retention (and between experience formation and experience retention) gives the losses corresponding to drop-out. And the difference between migration and drop-out is the loss of efficiency corresponding to non-return.

5. Relationships between stay and two independent variables. Two of the three independent variables of interest for this study are analyzed in their relationships to stay. These variables are length of training and research support facilities at former trainees' home organizations. The third variable of interest, training content, is not analyzed because of a methodological problem related to the circumstance that emphases on training have not been equal at different points in time for the four CIAT commodity programs. Consequently, average lengths of stay are not directly comparable between the corresponding four training contents.

The same four perspectives examined for the analysis of inventories are applied to the relationships between stay and independent variables. Therefore, "stay" will refer to the average number of years during which former trainees have worked for their sponsor organizations, fields of training, CIAT commodities, and research in general. Data have been processsed through analyses of variance which were conducted within each perspective and training content. They do not apply to comparisons between perspectives or between training contents.

a. Stay and length of training. An assumption in the design of training programs at CIAT with different durations has been that length of training is positively correlated with post-training performance. The rationale is that not only with more time is it possible to acquire more information and develop new skills, but that an "enduring" effect of training occurs as length increases. The intent of this study is not to examine in detail how length of training affects research performance, but to "check" in an exploratory way the presence or absence of the relationship with regard to stay as a single indicator of a dimension of research performance (stay).

Length of training is defined as the time from physical arrival at CIAT to departure from CIAT, measured in number of months. It is grouped in three categories: a) short training, when the duration was up to six months; b) intermediate training, when it took more than two months up to six months; and c) long training, for programs longer than six months.

b. Stay and research support facilities. The degree of facilities to do research in the fields in which former trainees carried out their training is a structural factor supposedly very influential in post-training research performance. It is assumed that stimuli as well as constraints may arise from the degree of facilities available to a person for continuing to actively engage in research.

In order to examine the presence or absence of a relationship between stay and research facilities, the Latin American and Caribbean countries which have sent professionals for training to CIAT were classified in eight groupings, two per commodity: those with more facilities to do research in each commodity, and those with less facilities (see pp. for details about this classification).

D. The researchers' networks: Data collection and analysis.

Data for the question on network participation was also designed to be collected from the whole population. This decision was made in regard to the nature of this type of analysis. In general, current network analysis procedures are better suited to population studies than to samples (Farace and Mabee, 1980, p. 384); attempts to develop sampling techniques for network analysis have been advancing, but they still are at an exploratory stage (Granovetter, 1976). The population for this part of the study is defined as composed of those former CIAT research trainees who, after training, engaged in research even for a brief period.

1. The instrument for collecting network data is a questionnaire (a Spanish version is in Appendix E) on the interchange of research with colleagues and personal data.

a. Interchange of research. Former trainees are asked to write names, organizational affiliation, and country of those colleagues with whom they seriously interchanged views and resources about research work and professional interests during the last year. Interchanges are asked at four levels: within respondent's organization, or country, within Latin America, and in the rest of the world. They were also asked to indicate the intensity of each interchange in frequency and depth. Frequency of interchanges is reported by checking one of two categories: often, or not often. "Often" meant several times during the year. "Not often" meant once a year or less. Depth of interchanges is indicated by checking one of two categories: deep, or superficial. In order to record such data, an empty table is provided. A hypothetical example is presented about how to answer the network question.

b. Personal data. Five items are asked about the respondent: i) name; ii) institution where currently working; iii) country where currently working; iv) number of years of experience doing research; and v) current research area, e.g., rice, beans, tropical pastures, cassava, other.

2. Tactics for data collection. Instruments for network data were pre-tested at Michigan State University. In Colombia they were tested again with persons carrying out their training at CIAT by that time (May to July, 1980). Although the item about research interchanges seems complex when presented as a research technique, respondents usually do not find difficulties in answering it. That was the original experience at Michigan State University, confirmed later during its testing in Colombia.

There was some concern about the use of the Spanish version of the network questionnaire for Brazilian people, whose native language is Portuguese. Instruments were translated, but during the testing it was realized that more difficulties appeared when using both languages than when using only Spanish. Therefore, Spanish was the language used for data collection.

Attached to the network questionnaire was a personalized letter (see its Spanish version in Appendix D). It followed the same format of the letter signed by the Director General of CIAT and was mailed with the census. In the case of the network questionnaire the letter was signed by the investigator who carried out the study, jointly with the coordinator of the CIAT training programs.

Mailing of network instruments is dependent on receiving census data, not only because lack of trainees' current personal addresses, but also because network analysis results are relevant only for those people who performed research related roles after training. Mailing started very slowly by August, 1980. Due to time and financial constraints, it was decided to analyze only the network data available at the end of January, 1981. After a screening procedure, 207 complete questionnaires (38 percent) resulted out of the 542 which were sent to those former trainees who performed research related roles after training, and for whom addresses were known. At the moment of writing this dissertation approximately 400 answered questionnaires have been received.

3. Network analysis. A persistent interest in analyzing social phenomena in terms of networks has resulted in a set of concepts and research techniques called network analysis. It has received contributions from a diversity of disciplines such as anthropology,

sociology, social psychology, demography, geography, mathematics, communication, and others (Asch, 1975, pp. 26-45).

In general, concepts and analytic techniques are built on Barnes' idea of network (1954) as a set of points, some of which are joined by lines. The points are people, or sometimes groups, and the lines indicate which people interact with each other. When the aim is to decipher network structure, the appropriate techniques must be relational in nature (Farace and Mabee, 1980; Rogers, 1981). A technique of this type with its corresponding set of concepts was elaborated by Richards (1975) and packaged in a computer program called NEGOPY.

Network data for this dissertation were processed by the NEGOPY program. Following are pertinent concepts and definitions based on Richards' description of that computer program (1975).

The points representing persons in the network are called nodes, and the relationships between them links. Whenever a person reports a relationship with another person, there would be a link between the corresponding pair of nodes.

Links may be directional or undirectional. Directional links leave open the possibility of unreciprocated relationships. Undirectional links imply reciprocity. Directional links which are reciprocated and have equal weight imply symmetry in the relationship. Lack of reciprocation or unequal weight in directional links implies assymetrical relationships.

a. Participants and non-participants. The analysis of the network by NEGOPY starts by classifying all nodes in terms of two general roles: participants and non-participants. Participants are the nodes that take part in the bulk of interchanges with other

participants. The non-participants include all the nodes having either no connection or only minimal connection to participants.

b. Third cultural character of networks. Once participants in the network are identified, the next step in this analysis is to examine the third cultural character of linkages among participants. This is not made by NEGOPY. This is accomplished by studying the loci of incidence and types of linkages of participants.

i) Locus of incidence. If researchers have links beyond their organizations and countries this is an indication that their interchanges are not totally domestic, but transnationality exists in some proportion of those connections.

ii) Types of linkages. Three of the four of the Useems' conceptual categories for classifying and enumerating types of networks (pp. 59-60) are selected for guiding the analysis of types of linkages: latent, nascent, and intensive ties. They are operationalized for this study in terms of two dimensions of intensity of interactions: frequency and depth.

At the operational level, latent links are characterized by person-to-person interactions occurring frequently and superficially. Nascent links correspond to more frequent but still limited in scope interactions. And intensive links are those which are deep in nature; two sub-categories of intensive personalized ties are further differentiated here: those which do not occur very often, labeled intensive links of sub-type one; and those interactions which, in addition to being deep in nature, take place frequently; the latter are called in this study intensive links of sub-type two. An assumption implicit in this entire operationalization is that the same person can have all types of linkages; with some colleagues the

relationship can be of a latent type; with others, it can be nascent; and so on for the intensive types.

Finally, the intensive nature of transnational linkages needs to be examined for gaining evidence about the third cultural character of networks. If transnational linkages are predominantly nascent or latent, then third cultures are not very likely to emerge within those networks. This is checked by cross-tabulatng locus of incidence and type of linkage.

c. Network structure. The social structures emerging out of the networking activities are identified by classifying participants and non-participants in more specific network roles (see Figure 3 taken from Richards 1975, p. 7). Non-participants include four types of roles: a) isolates type 1 are nodes which have no links whatsoever; b) isolates type 2 or attached isolates are nodes having only a single link, and thus their participation in the network is very restricted; they may, however, function as sources of information and other resources if they have links outside the network; c) members of isolate dyads are pairs of nodes linked to each other, but without connections to the rest of the network; and d) if there is a subset of nodes with minimal connections, the subset will be a tree structure composed of isolates and tree nodes; the isolates will be the nodes at the ends of the structure, and will have only single links; the tree nodes are the other nodes in the structure.

Participants include three types of roles: a) group members, which are nodes with more than fifty percent of their linkage with other members of the same group; group members who are linked to members of other group(s) constitute a special subcategory called bridges; b) liaisons are those nodes which have very intensive

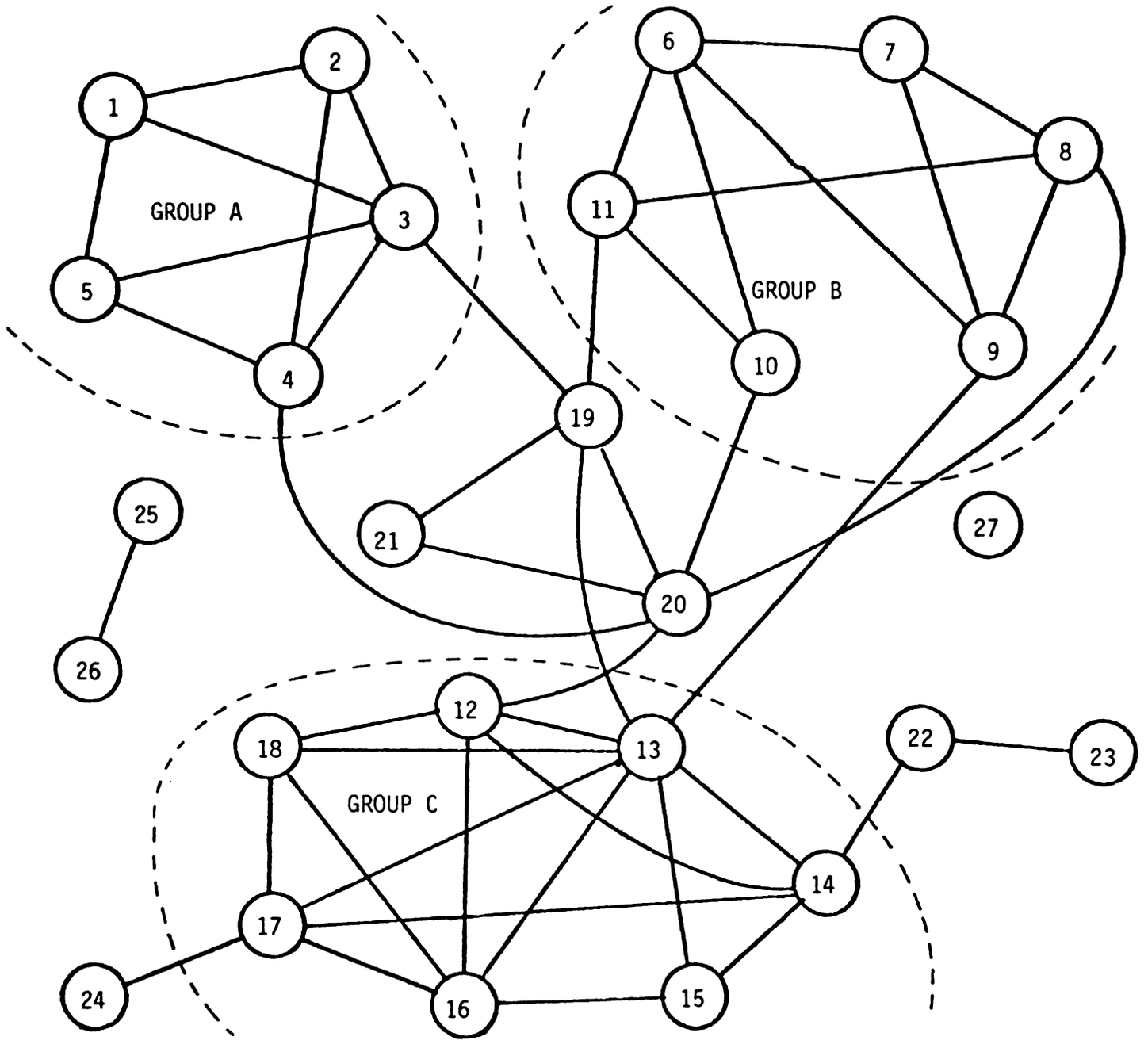

Figure 3. Network roles. (Taken from Richards, 1975, p. 7).

Participants
Group members. Group A: 1, 2, 3, 4, 5. Group B: 6, 7, 8, 9, 10, 11.
Group C: 12, 13, 14, 1 , 1 , 1 , 1
Liaisons: 19, 20.
Others: 21.

Non-participants
Isolate type 1: 27.
Isolate type 2: 23, 24.
Isolated dyad: 25, 26.
Tree node: 22.

interchanges with members of several groups without being members of any of those groups; and c) type "others" are participants in the network which are not group members or liaisons.

To be called a group, a set of nodes must satisfy the following criteria: a) more than half of the communication of the members of a group is with each other; b) each member is linked to all members on a direct or indirect basis; c) no single link nor member can be eliminated and have the group break apart; and d) each group should consist of at least three members.

4. Relationships between participation and three independent variables. These relationships are tested by means of chi-square tests. This test is appropriate because of the nominal nature of the structural categories (participation, non-participation; specific network roles). When relationships are supported by statistical significance in the tests, additional more detailed examination is carried out by cross-tabulating each independent variable with the proportion of group members, which represent the more salient role in a research network. (Liaisons are also of great importance in a research network, but they usually are very few, so comparisons are only rarely feasible). Another analysis of relationships is made by computing the number of links per person at each locus of incidence, and then cross-tabulating loci of incidence with independent variable strata.

CHAPTER IV

Findings of the Study, Part I:

INVENTORIES OF HUMAN RESOURCES FOR AGRICULTURAL RESEARCH

This chapter focuses on the return of former CIAT trainees to their organizations and their length of stay in the activity of research. It examines the question of, to what extent are the Latin American countries building inventories of human resources for agricultural research, based on CIAT's training?

The first section deals with the central question of inventory formation: 1) CIAT's contribution to preparing agricultural researchers for the region; 2) effectiveness, and 3) efficiency of the region in forming researchers' inventories based on CIAT's training; 4) migration of researchers as a source of inefficiencies; 5) stay in and retention for the activity of research; and 6) inventories of research experience.

The last portion of the chapter explores the presence of relationships between stay in research and two independent variables: length of training, and facilities to do research in the fields of training at sponsor organizations.

A. Inventory formation.

1. CIAT's contribution. The contribution of CIAT to the formation of inventories of agricultural professionals in Latin America during the period 1969-79 is indicated by the number of persons trained. The review of training files carried out for the purpose of this dissertation shows that during the period a total of 1413 professionals from various parts of the world utilized the training opportunities provided by CIAT. Most of them (89.1%) are from Latin America. The rest are distributed almost evenly between Africa, Asia, and Austrailia (4.6%), and North America and Europe (6.3%).

Figures corresponding to Latin American professionals are arranged in Table 12 in terms of three types of training: a) production and extension, b) research support, and c) research. A segment of this last type of training (enclosed within discontinuous lines in Table 12) is the center of attention for this dissertation. It comprises training in research in CIAT's present four commodity programs. A set of 783 persons, representing 62% of the total for the period 1969-79, constitute the study population.

2. Effectiveness. The source of data for the analysis of human resource inventories is a census conducted for this thesis in the 182 organizations which sent personnel to CIAT for research training. From the population of 783 professionals who completed their training in research between 1969 and 1979, data were obtained for 580 persons. The average rate of response for the total period was 74% (Table 13).

The extent to which former CIAT trainees have reentered their sponsor organizations and stayed active in research is analyzed here from the envisioned points of view of four different sets of people:

Table 12. Former CIAT trainees from Latin America distributed by training content.

Training content	N	%
Production and extension	201	16.0
Crop production*	57	4.5
Beef production*	46	3.7
Seed production	98	7.8
Research support	116	9.2
Biometrics and data processing	6	0.5
Communications	9	0.7
Documentation	41	3.3
Station operations	38	3.0
Others	22	1.7
Research	942	74.8
CIAT's commodities	783	62.2
Rice	173	13.7
Beans	245	19.5
Tropical pastures	172	13.7
Cassava	193	15.3
Other research	159	12.6
Economics**	12	1.0
Swine production***	85	6.7
Corn	20	1.6
Weed control	42	3.3
TOTAL	1259	100.0

* Actual number of participants in crop and beef production is larger because some trainees participated in both production and research training. They are assigned to research in order to not double count the number of participants.

** These are only the participants in training in economics who cannot be specifically classified within any of the other research categories. The actual number of trainees in economics is larger.

*** Swine training includes both research and production. It was decided to classify this as research training.

[ ] Study population.

Table 13. Population and sample of former CIAT research trainees (1969-79), distributed by training content and year in which training was completed.

Year	RICE			BEANS			T. PASTURES			CASSAVA			TOTAL		
	n'_R	N_R	%	n'_B	N_B	%	n'_P	N_P	%	n'_C	N_C	%	n	N	%
1969	1	1	100	0	0	0	0	0	0	0	0	0	1	1	100
1970	3	8	38	0	0	0	0	0	0	2	2	100	13	21	62
1971	5	5	100	1	1	100	3	4	75	1	1	100	10	11	91
1972	17	34	50	3	3	100	8	9	89	3	3	100	31	49	63
1973	4	6	67	3	4	75	5	6	83	7	7	100	19	23	83
1974	8	15	53	2	5	40	8	12	67	25	29	86	43	61	70
1975	4	5	80	16	23	70	8	12	67	6	11	55	34	51	67
1976	7	10	70	20	22	91	12	19	63	25	40	63	64	91	70
1977	12	14	86	37	42	88	13	31	42	4	4	100	66	91	72
1978	13	26	50	55	66	83	23	31	74	38	48	79	129	171	75
1979	39	49	80	64	79	81	26	37	70	41	48	85	170	213	80
TOTAL	113	173	65	201	245	82	114	172	66	152	193	79	580	783	74

a) directors of sponsor organizations, b) coordinators of programs at the training organization (CIAT), c) directors of the training organizations, and d) country-based and international sponsors and science policy makers (see p. 6). For convenience of expression, these four perspectives will be respectively labeled, throughout the chapter: "sponsor organizations," "fields of training," "CIAT commodities," and "research in general."

The formation of inventories has increased during the period analyzed (Table 14). Annual net balances are positive for each of the four perspectives examined, and in all of them, increase final inventories. This process, however, has been more effective in the building of human resources for "research in general," and less effective for building inventories in specific "fields of training." The other two perspectives, "sponsor organizations" and "CIAT commodities," show intermediate effectiveness.

3. Efficiency. While final inventories show effectiveness in the process of forming resources for agricultural research, we can ask the further question: How efficient have these processes been? To examine this question, efficiency is defined as the percentage which final inventories represent with respect to the cumulative number of trained personnel. Efficiency is not calculated for the whole 11-year period because the personnel trained during the first years was relatively low in number. Efficiency rates appear in Table 15 starting with the year 1972.

Two tendencies are observed. First, efficiency in the formation of inventories for "research in general" and for "sponsor organizations" has been over 70 percent, while efficiency in building a "critical mass"

Table 14. Inventory formation for the period 1969-79, showing initial inventories, annual net balances, and final inventories for the four perspectives: organizations, fields of training, CIAT's commodities, and research in general (n = 580).

Perspectives	Years										
	1969	70	71	72	73	74	75	76	77	78	79
Sponsor organizations											
Initial inventory	0	1	12	20	49	61	101	123	172	218	308
Annual net balance	1	11	8	29	12	40	22	49	46	90	121
Final inventory	1	12	20	49	61	101	123	172	218	308	429
Field of training											
Initial inventory	0	1	7	14	29	40	64	81	107	143	222
Annual net balance	1	6	7	15	11	24	17	26	36	79	89
Final inventory	1	7	14	29	40	64	81	107	143	222	311
CIAT commodities											
Initial inventory	0	1	7	14	32	44	69	88	115	158	235
Annual net balance	1	6	7	18	12	25	19	27	43	77	94
Final inventory	1	7	14	32	44	69	88	115	158	235	329
Research in general											
Initial inventory	0	1	14	22	51	66	108	133	185	241	341
Annual net balance	1	13	8	29	15	42	25	52	56	100	129
Final inventory	1	14	22	51	66	108	133	185	241	341	470

Table 15. Efficiency in the formation of human resource inventories for agricultural research (n = 580).

Perspectives	Years							
	1972	1973	1974	1975	1976	1977	1978	1979
Sponsor organizations								
Cumulative trained personnel	55	74	117	151	215	281	410	580
Final inventories	49	61	101	123	172	218	308	429
Efficiency (%)	89.1	82.4	86.3	81.5	80.0	77.6	75.1	74.0
Fields of training								
Cumulative trained personnel	55	74	117	151	215	281	410	580
Final inventories	29	40	64	81	107	143	222	311
Efficiency (%)	52.7	54.0	54.7	53.6	49.8	50.9	54.1	53.6
CIAT commodities								
Cumulative trained personnel	55	74	117	151	215	281	410	580
Final inventories	32	44	69	88	115	158	235	329
Efficiency (%)	58.2	59.5	59.0	58.3	53.5	56.2	57.3	56.7
Research in general								
Cumulative trained personnel	55	74	117	151	215	281	410	580
Final inventories	51	66	108	133	185	241	341	470
Efficiency (%)	92.7	89.2	92.3	88.1	86.0	85.8	83.2	81.0

of professionals for establishing collaborative linkages with respect to CIAT commodities and particular "fields of training" has been much lower, oscillating between 50 and 60 percent. Second, from the four perspectives--"organizations," "fields of training," "CIAT commodities," and "research in general"--there seems to be a slight tendency toward decreasing efficiency in formation of inventories.

4. Migration. Tables 16 and 17 present migration broken down in its non-return and drop-out components (raw data for preparing these tables appear in Appendix E, Tables E-1 to E-6). Examining the cumulative effects of migration up to 1979, two conditions are evidenced: a) for the four perspectives, migration in the sample studied has been an extended phenomenon, ranging in magnitude between 19 percent, in "research in general," and 46 percent, in "fields of training," of the total trained personnel; and b) this process has eroded more heavily the human resources prepared for establishing collaborative research linkages among CIAT and counterpart organizations in the region (in "fields of training" and "CIAT commodities"), than for preparing personnel for country-based "organizations" and "research in general" (Table 16).

Looking at how the phenomenon has grown over the years, some tendencies are observed: migration is increasing from the perspectives of "sponsor organizations" and "research in general," while it seems to be stagnant--in spite of its high magnitude--for "fields of training" and "CIAT commodities" (Table 17).

The disaggregation of migration into its two components helps one to gain some insights about the preceding findings. Two immediate facts surface: a) drop-out is an extended phenomenon for the four perspectives studied, its cumulative effect up to 1979 being higher

Table 16. Cumulative effects of migration, drop-out, and non-return, up to the year 1979, expressed in absolute numbers and percentages of the total number of trained personnel (n = 580), and as percentages of migration within each perspective.

Perspectives	Drop-out		Non-return		Migration	
	Number	%	Number	%	Number	%
	Numbers and percentages of total trained personnel					
Sponsor organizations	102	17.6	49	8.4	151	26.0
Fields of training	86	14.8	183	31.6	269	46.4
CIAT commodities	90	15.5	161	27.8	251	43.3
Research in general	83	14.3	27	4.7	110	19.0
	Percentages of migration					
Sponsor organizations		67.5		32.5		100.0
Fields of training		32.0		68.0		100.0
CIAT commodities		35.9		64.1		100.0
Research in general		75.5		24.5		100.0

Table 17. Cumulative migration, drop-out, and non-return expressed as percentages of cumulative trained personnel (n = 580).

Perspectives	Years							
	1972	1973	1974	1975	1976	1977	1978	1979
Sponsor organizations								
Migration	10.9	17.6	13.7	18.5	20.0	22.4	24.9	26.0
Drop-out	1.8	5.4	5.1	8.6	9.8	12.8	15.9	17.6
Non-return	9.1	12.2	8.6	9.9	10.2	9.6	9.0	8.4
Fields of training								
Migration	47.3	45.9	45.3	46.4	53.0	59.1	45.8	46.4
Drop-out	3.6	4.1	2.6	4.6	7.0	8.9	11.2	14.8
Non-return	43.7	41.8	42.7	41.7	46.0	40.2	34.6	31.6
CIAT commodities								
Migration	41.8	40.5	41.0	41.7	46.5	43.8	42.7	43.3
Drop-out	3.6	4.1	2.6	4.0	6.5	7.8	11.7	15.5
Non-return	38.2	36.4	38.4	37.7	40.0	36.0	31.0	27.8
Research in general								
Migration	7.3	10.8	7.7	11.9	14.0	14.2	16.8	19.0
Drop-out	5.5	8.1	5.1	7.3	8.4	8.9	11.2	14.3
Non-return	1.8	2.7	2.6	4.6	5.6	5.3	5.6	4.7

than 14 percent of the total number of persons trained; and b)drop-out has its heaviest effects for "sponsor organizations" and "research in general," while non-return affects more the formation of inventories for "fields of training" and "CIAT commodities" (see absolute numbers and percentages of migration in Table 16). Is there any tendency over the years for the cumulative effects of drop-out and non-return? Percentages in Table 17, graphed in Figure 4, clearly suggest that, in general, drop-out is increasing, and non-return is decreasing or remains stagnant, with the exception of "research in general," where non-return has slightly increased.

5. Retention and stay. Retention (R) designates the number of persons who, after training, have continued working for their sponsor organizations ("fields of training," etc.). Retention rates are the percentages which retention absolute values represent with respect to the number of people trained during a given year. (Retention absolute values are the figues occupying the main diagonal in Tables E-1 to E-4, Appendix E).

This study is focused on the analysis of inventory formation over the period 1969-79, and not on comparing figures for individual years. Therefore, retention is not presented here on a separate annual basis, but cumulatively; figures corresponding to a given year incorporate retention in the preceding years (Table 18 and Figure 5).

For the sample studied, rates of cumulative retention follow a similar pattern of increase-decline-increase for the four perspectives, although decline lasts longer for "fields of training" and "CIAT commodities." The similarity in trends from the four perspectives might be associated with the impact that retention has on the high rates

Table 18. Cumulative retention, distributed by calendar years (n = 580).

Perspectives	Calendar years									
	1970	71	72	73	74	75	76	77	78	79
Sponsor organizations										
Trained personnel	14	24	55	74	117	151	215	281	410	580
Cumulative retention	5	12	29	34	56	75	112	159	271	429
Rate of cumulative retention	36%	50%	53%	46%	48%	50%	52%	57%	66%	74%
Fields of training										
Trained personnel	14	24	55	74	117	151	215	281	410	580
Cumulative retention	3	8	18	22	31	37	59	92	182	311
Rate of cumulative retention	21%	33%	33%	30%	27%	25%	27%	33%	44%	54%
CIAT commodities										
Trained personnel	14	24	55	74	117	151	215	281	410	580
Cumulative retention	3	8	19	23	33	40	64	101	193	329
Rate of cumulative retention	21%	33%	35%	31%	28%	26%	30%	36%	47%	57%
Research in general										
Trained personnel	14	24	55	74	117	151	215	281	410	580
Cumulative retention	6	14	36	41	71	95	140	190	304	470
Rate of cumulative retention	43%	58%	66%	55%	61%	63%	65%	68%	74%	81%

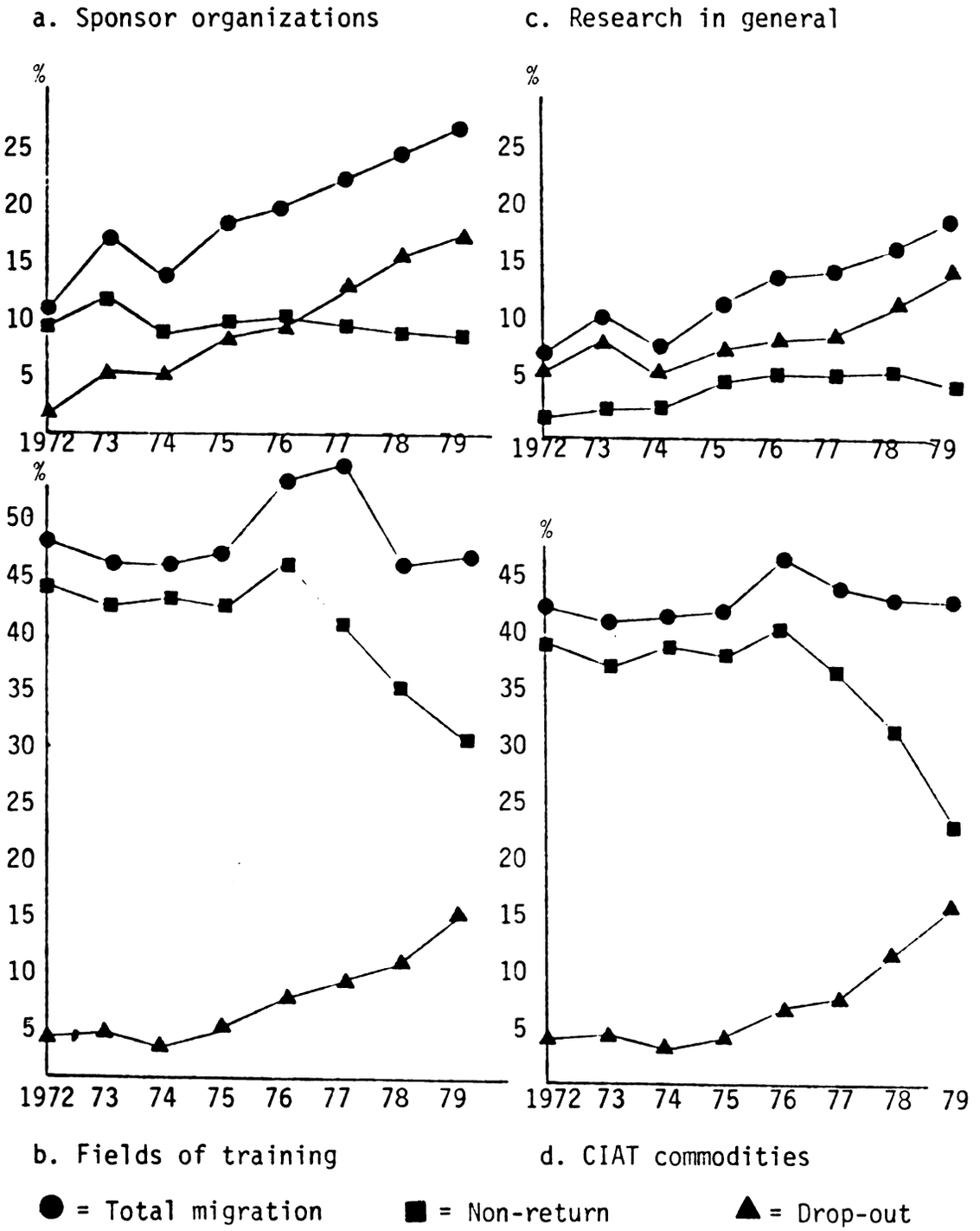

Figure 4. Cumulative migration, non-return and drop-out expressed as percentages of cumulative trained personnel, and graphed in terms of the corresponding calendar years (n = 580).

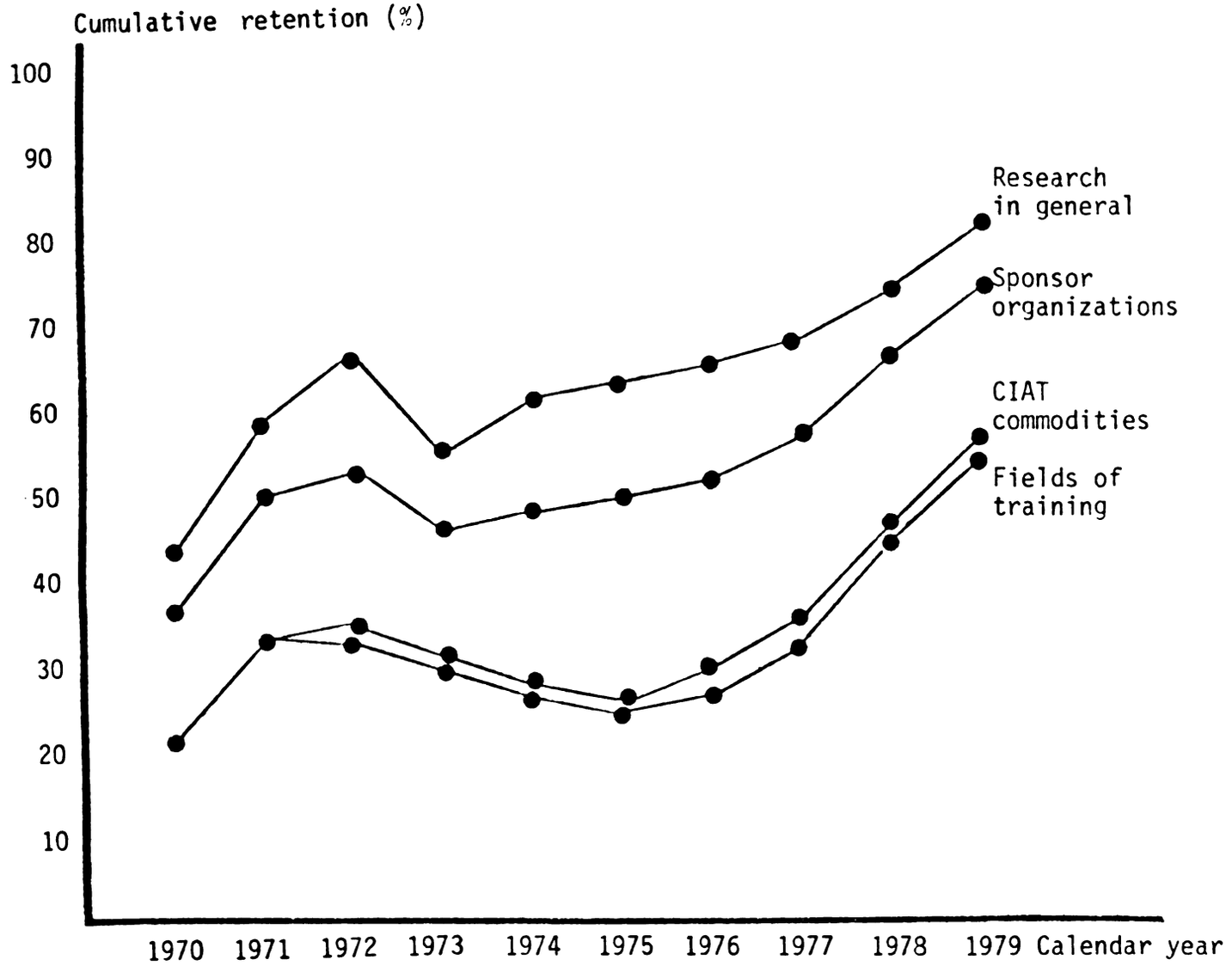

Figure 5. Rates of cumulative retention for the period 1970-79.

of non-return, particularly for the first half of the period. Non-return has affected more heavily "fields of training" and "CIAT commodities;" however, its tendency to decline for these two perspectives between 1976 and 1979 has allowed a relatively rapid recovery in the rates of retention.

Stay is a different factor from retention. Stay indicates the total number of persons who have not migrated up to a given year. Rates of cumulative stay decrease until an interval of six years for "fields of training" and "CIAT commodities," and until the seventh year for "research in general" and "sponsor organizations." Beyond these intervals, rates of cumulative stay appear to increase (Table 19 and Figure 6). These tendencies seem to support both directions of propensities to migrate and stay, suggested as possiblities in the study design (pp. 95-6). During the first six to seven years after training there is a propensity to migrate. In the other direction, data suggest that beyond six to seven years after training there is a propensity--among those professionals who still have not migrated--to stay in their organizations and fields of research.

The question of length of stay does not have a single answer for each perspective; it depends on the size of the interval after training. Rates of cumulative stay range between 95% and 34% for the different perspectives and intervals studied. Nine out of every ten former CIAT trainees have stayed for at least one year doing research after training; but out of every three professionals who have had the opportunity to stay at least six years, two have migrated from their fields of training. However, for those who have had the chance to stay nine years, rates range between 38% and 75% according to the different perspectives (Table 19 and Figure 6). These results raise the question of the extent to

Table 19. Cumulative stay distributed by number of years after training (n = 580).

Perspective	Number of years after training								
	1	2	3	4	5	6	7	8	9
Sponsor organizations									
Trained personnel*	580	410	281	215	151	117	74	55	24
Cumulative stay	531	345	210	146	98	70	41	32	15
Rates of cumulative stay	92%	84%	75%	68%	65%	60%	55%	58%	58%
Fields of training									
Trained personnel*	580	410	281	215	151	117	74	55	24
Cumulative stay	397	243	133	90	56	40	28	19	9
Rates of cumulative stay	68%	59%	47%	42%	37%	34%	38%	35%	38%
CIAT commodities									
Trained personnel*	580	410	281	215	151	117	74	55	24
Cumulative stay	419	258	146	98	61	45	31	21	9
Rates of cumulative stay	72%	63%	52%	46%	40%	38%	42%	38%	38%
Research in general									
Trained personnel*	580	410	281	215	151	117	74	55	24
Cumulative stay	553	363	230	170	116	86	49	40	18
Rates of cumulative stay	95%	89%	82%	79%	77%	74%	66%	72%	75%

* These figures represent the number of persons who meet the criterion of having at least 1, 2, . . . 9 years after training.

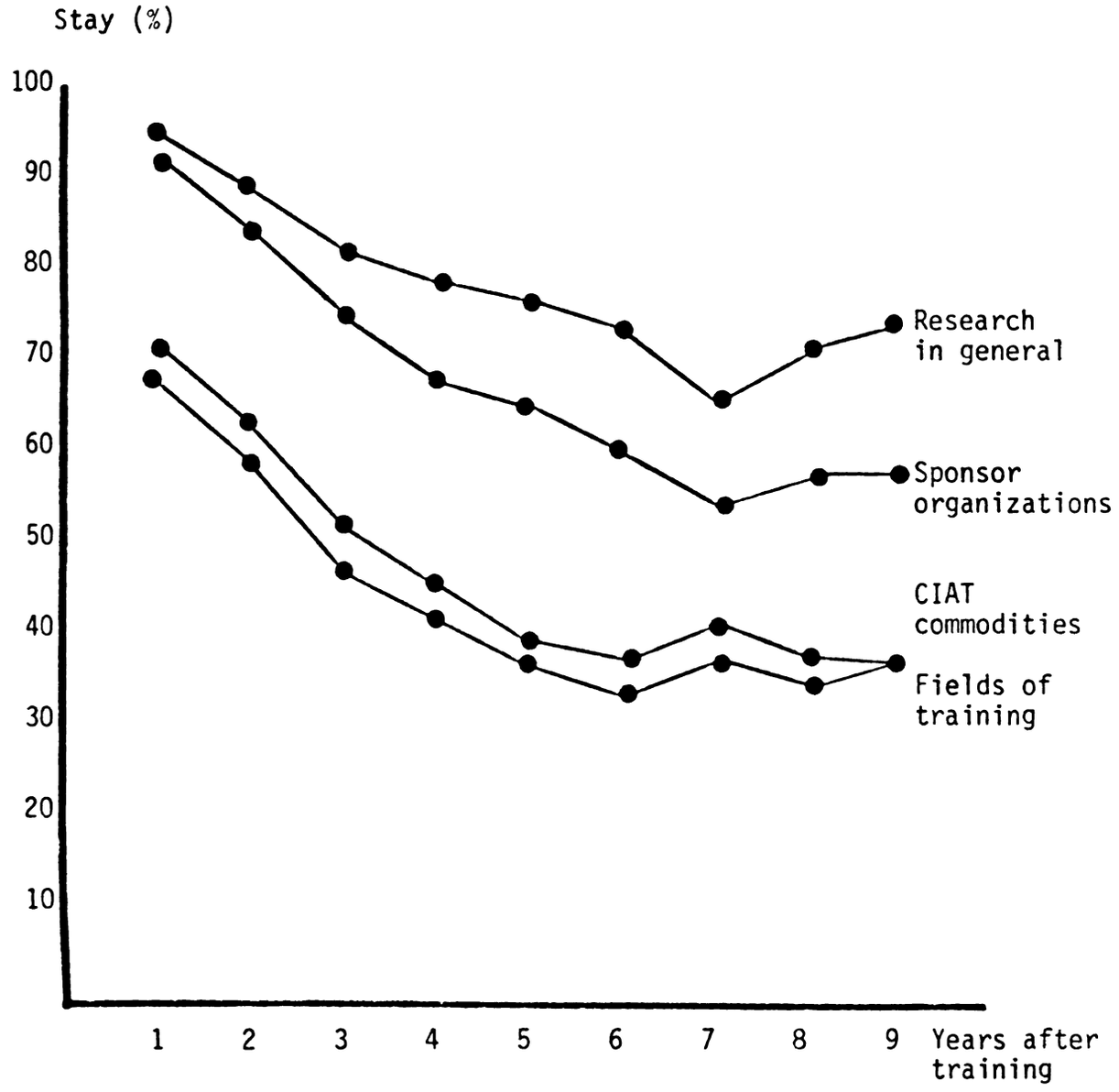

Figure 6. Rates of cumulative stay, distributed by number of years after training (n = 580).

which the region is building and retaining research experience with basis on the training carried out at CIAT. The following sections address this question.

6. Research experience. Retention and stay are closely related to one variable of much importance in scientific research: experience. In its essence, experience is generated cumulatively by doing. An unrefined indicator of experience is the number of years a person stays doing a given activity. This is an oversimplification because it assumes that every person is devoting 100% of their work time to that activity, and because it also assumes that one year of experience of person A is equivalent to one year of experience of person B, which might not be the case. However, for the purpose of getting a notion about what occurs in this sample with regard to experience formation and retention, this indicator is considered adequate.

Cumulative figures for experience formation and retention are presented in Table 20. They show--more vividly than figures expressed in number of persons--the erosion that migration causes on the inventories of human resources for agricultural research which Latin American countries have been building with basis on CIAT's training.

Efficiency in retention measured in person-years (experience) diminishes ten to fifteen percent in comparison to retention measured in number of persons. The impact on retention of the two components of migration is visualized in Figure 7 by means of circles, each one representing 100 percent. The percentages which appear inside the circles result from applying the following relationships to data from Tables 18, 19, and 20. The difference between efficiency in retention and 100 percent represents the lost efficiency corresponding to the

Table 20. Number of person-years and efficiency in the formation and retention of research experience, up to 1980 (n = 580).

Perspectives	Experience formation		Experience retention	
	Person-years	Efficiency	Person-years	Efficiency
Sponsor organizations	1494	78%	1183	62%
Fields of training	1019	53%	764	40%
CIAT commodities	1092	57%	814	42%
Research in general	1632	85%	1368	71%

cumulative effects of migration. The difference between efficiency in stay and retention (and between experience formation and experience retention) gives the losses corresponding to drop-out. And the difference between migration and drop-out is the loss of efficiency corresponding to non-return.

Figure 7 indicates that approximately 45 percent of the professionals who left their fields of training and research on CIAT commodities account for a loss of about 60 percent of the research experience which would have been built during the 11-year training period. And those who migrated from their sponsor organizations and research in general represent losses in research experience of about 40 percent and 30 percent, respectively.

Drop-out accounts for 13 to 16 percent of such losses, and non-return losses have ranged between 15 and 47 percent. The higher numbers for non-return do not mean that drop-out is a phenomenon of less importance. It should be recalled that drop-out shows a tendency to increase, when non-return seems to decline (Figure 4, p. 119).

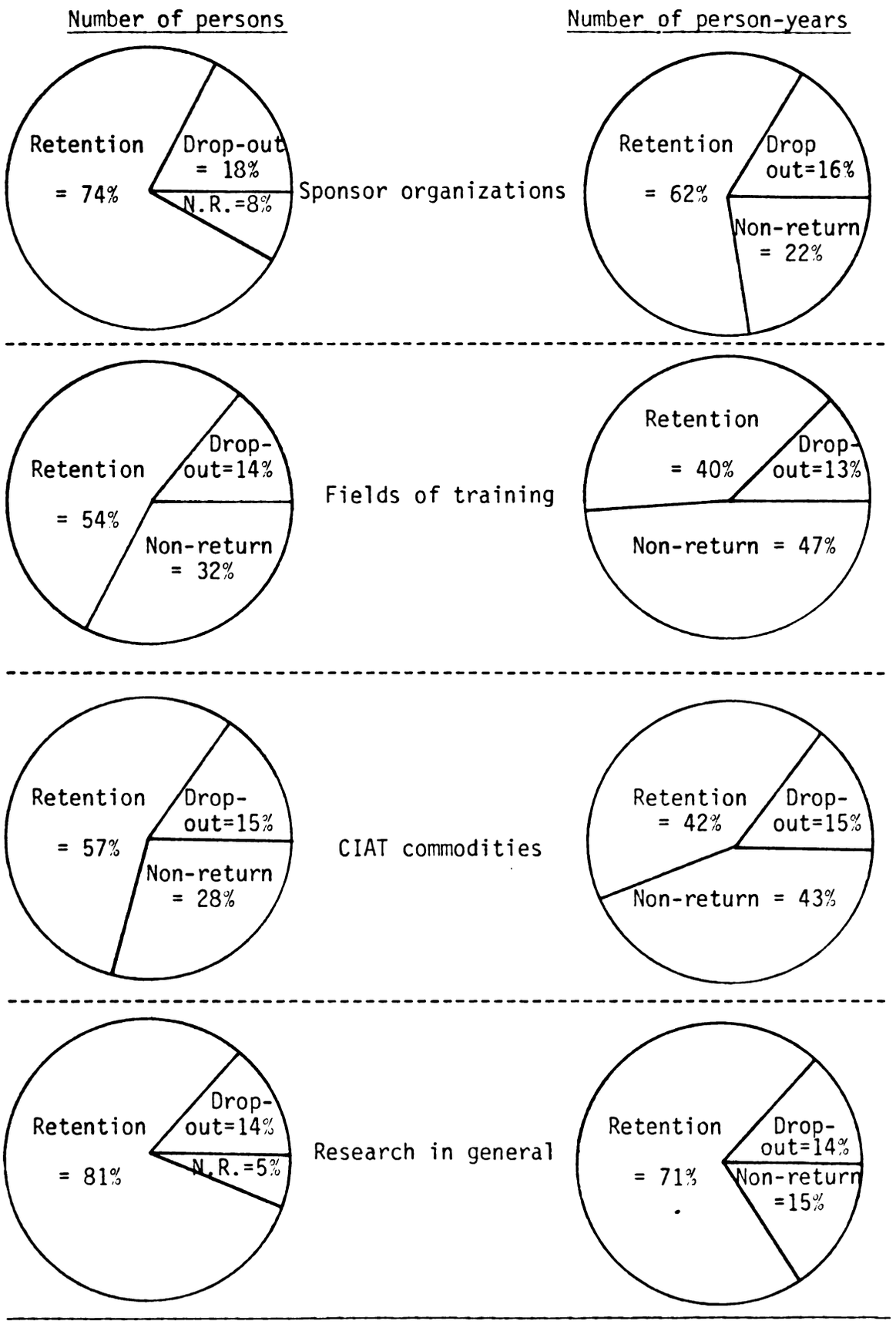

Figure 7. Cumulative retention, drop-out, and non-return for the eleven-year training period, measured as percentages of number of persons and number of person-years (experience).

A condensation of these findings (Table 21) reveals that, during the 11-year period studied, five percent of former CIAT trainees never worked in research, representing a total loss of 16 percent of the potential experience which could have been accumulated. Fourteen percent dropped out of research toward other activities, making up a loss of 13 percent of potential experience.

Table 21. Cumulative non-return, drop-out, and retention with respect to research activities for the 11-year training period expressed as percentages of trained personnel and percentages of person-years (n = 580).

	Percentages of trained personnel	Percentages of person-years
Non-return	5	16
Drop-out	14	14
Research other than CIAT	24	29
Migration within CIAT commodities	3	2
Retention in fields of training	54	40
TOTALS	100	100

Table 21 also presents condensed figures to answer two broad and central questions in relation to the formation of human inventories for agricultural research in Latin America and the Caribbean countries: What proportion of former CIAT trainees were still doing research in 1980? What proportion still continued working in the four areas in which they carried out their training?

The number of persons who have stayed doing research reaches a total of 81 percent, representing 71 percent of the cumulative

experience for the 11-year period. This 81 percent is distributed in the following way: 24 percent have kept doing research in areas different than CIAT endeavors; three percent moved from their original training area toward others within CIAT research commodities; and finally, 54 percent of the trained personnel have remained working in their fields of training, accounting for only 40 percent of the total potential experience.

B. Relationships between stay and two independent variables.

Two of the three independent variables of interest for this study are analyzed in their relationships to stay. These variables are length of training and facilities to do research at former trainees' home organizations.

The same four perspectives examined in the preceding analysis are also studied in this section. Therefore, "stay" will refer to the average number of years during which former trainees have worked for their "sponsor organizations," "fields of training," "CIAT commodities," and "research in general." Data have been processed through analyses of variance which were conducted within each perspective and training content. They do not apply to comparisons between perspectives or between training contents.

1. Stay and length of training. An assumption in the design of training programs at CIAT with different durations has been that length of training is positively correlated with post-training performance. The rationale is that not only with more time is it possible to acquire more information and develop new wkills, but that an "enduring" effect of training occurs as length increases. The intent of this study is not to examine in detail how length of training affects research performance, but to "check" in an exploratory way the presence or absence of the

relationship with regard to stay as a single indicator of a dimension of research performance (stay).

Length of training is defined as the time from physical arrival to CIAT to departure from CIAT, measured in number of months. It is grouped in three categories: a) short training, when the duration was up to two months; b) intermediate training, when it took more than two months up to six months; and c) long training, for programs longer than six months.

Results of analyses of variance (Table 22 and Figure 8) support the existence of a positive relationship between stay and length of training. Most comparisons of means are statistically different at an alpha level of 5%. However, the high heterogeneity of the data should be noticed, revealed by large standard deviations.

Such high variability may be tied to individual, organizational, and socio-economic-cultural factors which may affect average stay and are not controlled in this study. Large standard deviations may also be related to the way in which analyses were carried out, aggregating training in only three categories: short, intermediate, and longer training. A further analysis of these issues is beyond the scope of this thesis.

A closer look at the patterns of the relationship stay-length suggests some tendencies for the perspectives and commodities within which the analysis is carried out (Figure 8). In general, the relationship is clearer for "research in general" and "sponsor organizations." This is more evident in the cases of rice and beans. For the perspective "fields of training" there are no statistical differences in the cases of beans and cassava, which indicates that the relationship does not

Table 22. Summary of the analyses of variance for the dependent variable stay (number of years) as a function of the independent variable length of training. (Comparisons are not between contents or perspectives.)

Content/Perspective	Two months or less	More than two months, up to six	More than six months	Total	
Rice	(n" = 43) $\bar{x}$"	(n" = 57) $\bar{x}$"	(n" = 13) $\bar{x}$"	(n' = 113) $\bar{x}$'	$S\bar{x}$'
Sponsor organizations	2.58 B	3.46 B	5.69 A	3.38	2.88
Fields of training	1.49 B	3.11 A	2.62 AB	2.43	2.70
CIAT commodities	1.49 A	3.11 A	3.23 A	2.50	2.73
Research in general	2.67 B	3.67 B	6.08 A	3.57	2.86
Beans	(n" = 107) $\bar{x}$"	(n" = 70) $\bar{x}$"	(n" = 24) $\bar{x}$"	(n' = 201) $\bar{x}$'	$S\bar{x}$'
Sponsor organizations	1.65 B	2.33 A	2.79 A	2.02	1.38
Fields of training	1.25 A	1.79 A	1.88 A	1.51	1.47
CIAT commodities	1.35 B	1.86 A	2.33 A	1.64	1.44
Research in general	1.68 C	2.56 B	3.58 A	2.21	1.42
Tropical pastures	(n" = 22) $\bar{x}$"	(n" = 46) $\bar{x}$"	(n" = 46) $\bar{x}$"	(n' = 114) $\bar{x}$'	$S\bar{x}$'
Sponsor organizations	2.05 B	2.02 B	3.67 A	2.69	2.46
Fields of training	1.09 B	1.33 B	2.24 A	1.65	2.14
CIAT commodities	1.73 A	1.33 A	2.30 A	1.80	2.25
Research in general	3.05 AB	2.13 B	4.17 A	3.13	2.51
Cassava	(n" = 114) $\bar{x}$"	(n" = 14) $\bar{x}$"	(n" = 24) $\bar{x}$"	(n' = 152) $\bar{x}$'	$S\bar{x}$'
Sponsor organizations	2.39 B	3.07 AB	3.42 A	2.62	1.96
Fields of training	1.60 A	2.21 A	1.63 A	1.66	1.78
CIAT commodities	1.66 A	2.29 A	2.21 A	1.80	1.88
Research in general	2.54 B	3.86 A	3.46 A	2.81	2.01

Note: Means with the same letter are not significantly different. Alpha level = 0.05.

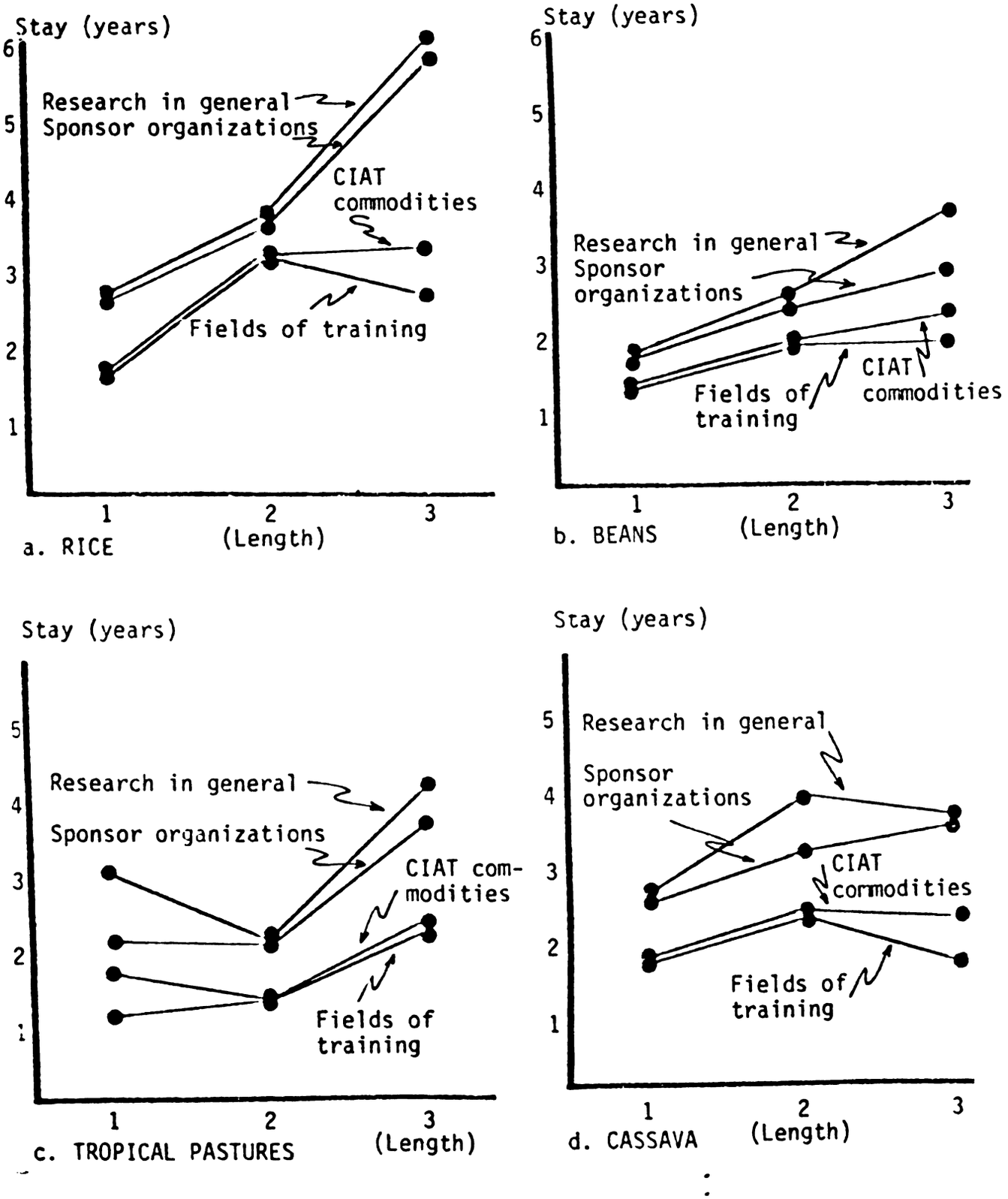

Figure 8. Average number of years of stay within sponsor organizations, fields of training, CIAT commodities, and research in general, for the training contents: rice, beans, tropical pastures, and cassava. Stay is graphed as a function of length of training. (1 = short training, 2 = intermediate training, and 3 = longer training).

exist or it is very weak. This is also the case for the comparisons between short and intermediate training in tropical pastures, and between intermediate and longer training in rice. However, for "fields of training" the positive relationship is very clear in the comparison between short and intermediate training, in the case of rice.

2. Stay and facilities to do research. The degree of facilities to do research in the fields in which former trainees carried out their training is a structural factor supposedly very influential in post-training research performance. It is assumed that stimuli as well as constraints may arise from the degree of facilities available to a person for continuing to actively engage in research.

In order to examine the presence or absence of a relationship between stay and research facilities, the Latin American and Caribbean countries which have sent professionals for training at CIAT were classified in eight groupings, two per commodity: those with "more" facilities to do research in each commodity, and those with "less" facilities (see pp. 78-81 for details about this classification).

None of the means compared exhibited statistical differences at an alpha level of 5% (Table 23). Therefore, data do not support the existence of a relationship between "stay" and "facilities to do research." Or, at least, such a relationship is very weak in these data, and consequently significant differences could not be detected. Similar to the case of "length of training," the size of standard deviations for "research facilities" is large.

In spite of the fact that differences are not statistically different, a slight relationship seems to be suggested by the data. Two thirds of the actual values of average stay are higher for trainees

Table 23. Summary of the analyses of variance for the dependent variable stay (number of years) as a function of the independent variable facilities to do research at sponsor organizations.

Content/Perspective	Facilities: More	Facilities: Less	Total	
Rice	(n" = 91)	(n" = 22)	(n' = 113)	
	$\bar{x}$"	$\bar{x}$"	$\bar{x}$'	$S\bar{x}$'
Sponsor organizations	3.58	2.54	3.38	2.78
Fields of training	2.51	2.09	2.43	2.70
CIAT commodities	2.60	2.09	2.50	2.73
Research in general	3.81	2.54	3.57	2.86
Beans	(n" = 126)	(n" = 75)	(n' = 201)	
	$\bar{x}$"	$\bar{x}$"	$\bar{x}$'	$S\bar{x}$'
Sponsor organizations	1.99	2.08	2.02	1.38
Fields of training	1.53	1.48	1.51	1.47
CIAT commodities	1.64	1.64	1.64	1.44
Research in general	2.21	2.23	2.21	1.41
Tropical pastures	(n" = 64)	(n" = 50)	(n' = 114)	
	$\bar{x}$"	$\bar{x}$"	$\bar{x}$'	$S\bar{x}$'
Sponsor organizations	2.73	2.64	2.69	2.46
Fields of training	1.50	1.84	1.65	2.14
CIAT commodities	1.59	2.06	1.80	2.25
Research in general	3.27	2.96	3.13	2.51
Cassava	(n" = 110)	(n" = 42)	(n' = 152)	
	$\bar{x}$"	$\bar{x}$"	$\bar{x}$'	$S\bar{x}$'
Sponsor organizations	2.61	2.64	2.62	1.96
Fields of training	1.72	1.50	1.66	1.78
CIAT commodities	1.83	1.74	1.80	1.88
Research in general	2.84	2.74	2.81	2.01

Note: All means are not statistically different at alpha level = 0.05.

whose sponsor organizations are classified as having "more" research facilities than those with "less" facilities.

A possible explanation for the lack of significant differences is that the categories applied in this study are very gross categories. Another possibility is that all members of this sample have the minimum level of research facilities, under which people are restricted from doing research. This last explanation might be supported by the circumstance that agricultural research tends to be non-capital intensive. Speaking in general terms, most agricultural research activities do not appear to require costly investments in labs and sophisticated equipment. Even the ownership of land and buildings for experimental stations does not seem to be essential, as illustrated by the case of the Instituto de Ciencia y Tecnologia Agricola (ICTA) of Guatemala, where researchers have been effectively conducting most of their research work off stations on farmer's land.

CHAPTER V

Findings of the Study, Part II:
THE SOCIAL STRUCTURES AND
THIRD CULTURES OF THE RESEARCHERS' NETWORKS

This chapter examines former CIAT trainees as practitioners who participate in varied types of networks among agricultural researchers. It starts with a brief description of the population and sample for network analysis.

The analysis begins by partitioning individual researchers in two categories, participants and non-participants.

Then the "third cultural" nature of these networks is delineated through the analysis of participants' linkage on two dimensions: "locus of incidence" and "types of links." Transnationality, the special characteristic of these networks, emerges from sorting the sample linkage with research colleagues into four mutually exclusive loci of incidence: 1) within respondents' organizations, 2)outside their organizations but inside their country, 3) in the rest of Latin America but outside respondents' country, and 4) in the rest of the world but outside the region. The issue of types of linkages characterizing this sample is analyzed by using the Useems' conceptual categories of intensive, nascent, and latent ties. (see pp. 59-60).

Following that, network structure is examined in terms of the roles that individual researchers perform in these third cultural networks as members of research groups, liasons between groups, other

participants, as well as components of various types of non-participants.

Finally, former CIAT trainees' participation in research networks is related to the three selected independent variables of this study: training content, length of training, and research facilities.

A. Population and sample.

The population for this study of the networks of researchers consists of former CIAT research trainees who, after training, engaged in research, even if for a brief period, and for whom current addresses are known. From the 580 persons for whom data were obtained in the census of organizations (p. 109 and Table 13), 553 professionals did research after training. Current addresses were identified for 542 of these persons, to whom network questionnaires were mailed.

In view of time and financial limitations a relatively short time interval was set for initiating data processing. Hence, the sample analyzed in this chapter includes only 207 questionnaires received by the end of January, 1981. (At the moment of writing this thesis, approximately 400 answered questionnaires have been received.)

According to the three variables, proportionate distributions by "training content," length of training," and "research facilities" are not substantially discrepant to the proportions in which the total number of persons trained are distributed (Table 24). "Length of training" is represented in exactly the same proportions. "Training content" shows a 13 percent over-representation for beans, which correspondes to under-representation for rice, tropical pastures, and cassava. As for "research facilities," the individuals with "more" facilities are 7 percent over-represented, and individuals with "less" facilities are under-represented in the same proportion.

Table 24. Former CIAT trainees who compose the sample for network analysis, distributed by training content, length of training, and facilities to do research at home organizations.

Variable	n	%	Total %*
Training content	207	100	100
Rice	32	16	22
Beans	92	44	31
Pastures	41	20	22
Cassava	42	20	25
Length of training	207	100	100
Two months or less	102	49	49
More than two, up to six months	69	33	33
More than six months	36	18	18
Facilities to do research	207	100	100
More facilities	151	73	66
Rice	27	13	17
Beans	67	32	19
Pastures	24	12	11
Cassava	33	16	19
Less facilities	56	27	34
Rice	5	2	5
Beans	25	12	12
Pastures	17	8	11
Cassava	9	5	6

* Percentage distribution of trainees within the total number of persons trained in research during the period analyzed.

B. Participants and non-participants.

These 207 former CIAT trainees reported that altogether, at the time of answering their questionnaires, they has ties with a worldwide community of 1413 agricultural researchers. The multitude of inter-relationships among the members of this community are classified by the intensity and direction of their interchanges by using the computerized NEGOPY program (p. 102). Roughly, about two thirds of them (141 trainees) were classified as participants in networks of researchers, and the rest were identified as non-participants.

C. Third cultural character of former CIAT trainees' networks.

According to the Useems' sociological construct (pp. 55-60) members of third cultures are people who relate their societies to each other through continued interactions which, in essence, are personalized but do not require continuing face-to-face encounters. These relationships prevail among scientific researchers who do not have the same nationality or organizational affiliation, but are widely scattered throughout the world, working for different countries and organizations. What keeps those interactions alive is not kinship or location ties, but the sharing of cognitive goals and experiences: their research problems. By means of these interchanges, researchers create new social groupings; they are members of small transnational communities. Participants carry into these communities cultural elements of their respective indigenous societies; from the interaction between cultural elements of the inter-dependent societies, new cultural forms arise--third cultures--which are shared by network members and passed on to newcomers to these new social groupings. In such ways bi-national, multi-national, and worldwide third cultures of science and technology are created, maintained, and shared by participants in networks of researchers.

To examine the nature of the networks in which former CIAT trainees participate, two dimensions of their linkages are analyzed: locus of incidence and type of linkage. Locus of incidence refers to the location of the interacting persons mentioned by respondents. Type of linkage refers to the frequency and depth of the interactions.

1. Locus of incidence. An aggregate of links are presented in Table 25. The 141 former CIAT trainees who participate in networks report a relatively high incidence of links with their significant others; on the average, 9.3 links per person. Nearly three out of every four ties are with other researchers within their immediate organizations and home countries. Within Latin America one in every five has personal ties with researchers working for organizations and countries other than their own. Close to seven percent have linkages outside the Latin American region in some part of the rest of the world.

Table 25. Locus of incidence of links reported by network participants.

Locus of incidence	Number of links	Percentage of links	Links per individual
Own organization	529	40.4	3.75
Home country	429	32.8	3.04
Latin America (Outside their country)	261	20.0	1.85
Worldwide (Beyond Latin America)	89	6.8	0.63
TOTAL	1308	100.0	9.28

These results indicate that the total of former CIAT trainees' linkages are primarily oriented toward their own work organization and home country. However, these networks are not totally domestic. To put it in the larger transnational setting, over a fourth of trainees have connections with fellow researchers beyond their home land. These encounters open up the possibility for third cultures of science and technology to emerge within segments of these agricultural researchers.

2. Type of linkage. Six out of every nine links are of an intensive nature. Relationships of sub-type two--more intensive--are about twice as common as those of sub-type one. The other three out of nine links constitute latent and nascent interactions, with the latent being approximately double the nascent ties (Table 26).

Table 26. Number of links reported by network participants, distributed by type of linkage.

Type of linkage	Number of links	Percentage of links	Links per respondent
Latent	286	21.8	2.02
Nascent	150	11.6	1.07
Intensive, sub-type one	284	21.7	2.01
Intensive, sub-type two	588	45.0	4.17
TOTAL	1308	100.0	9.28

However, hypothetically it is possible that intensive ties concentrate within organizations and countries, and transnational relationships might be only of a nascent or latent character. To check these possibilities, and explore in more detail the third

cultural nature of the networks in which former CIAT trainees participate, the relationships reported by participants are cross-tabulated according to "locus of incidence" and "type of linkage" (Table 27). This cross-tabulation shows that almost one third of the intensive relationships occur at the regional or world levels, that is to say with people from outside of respondents' own organization and country.

Table 27. Linkages of network participants, distributed by locus of incidence and type of linkage.

Locus of incidence	Type of linkage: Latent Links	%	Nascent Links	%	Intensive 1 Links	%	Intensive 2 Links	%	Total Links	%
Organization	131	10.0	61	4.7	100	7.6	237	18.1	529	40.4
Country	88	6.7	57	4.4	84	6.4	200	15.3	429	32.8
Latin America	59	4.5	22	1.7	65	5.0	115	8.8	261	20.0
World	8	0.6	10	0.8	35	2.6	36	2.8	89	6.8
TOTAL	286	21.8	150	11.6	284	21.6	588	45.0	1308	100.00

In summary, the analyses of locus of incidence and type of linkage of CIAT-trained researchers with relevant colleagues provides evidence that third cultural networks of science and technology are being created, maintained, and shared in particular fields of agricultural research in the region.

D. Network structure.

This analysis follows the conceptual framework presented in pages 45 to 60 and the methodology described in pages 102 to 106. The research community is the wider concept; it is composed of all those persons who occupy research positions in their societies as a central

part of their work activities. The research community is not a uniform, homogeneous entity, but a multitude of loosely defined clusters of interrelated individuals.* Some of these persons participate in more than one cluster, acting as the junctures of two or more intersecting clusters. This overlapping, as well as other factors such as the size of the research community, its lack of geographical or political boundaries, and the non-formalized nature of the relationships among researchers, creates a high complexity which makes it difficult to study the research community in its entirety.

The concept of research networks provides a more workable specification of the above-mentioned clusters. A research network is a subset of the research community integrated by researchers whose attention is focused on closely related research problems. This definition allows one to include in the study of a given network the more active members who are well interconnected with each other (participants), and also those potential members (non-participants) who have very few or no connections within that particular network.

When interchanges among researchers are continued and intense enough, their networks become more structured; differentiation of roles emerges as evidence of increasing social organization. A high degree of structure in a research network is characterized by the development of some special groupings called "invisible colleges" in the sociology of science.

In this thesis the terms "invisible college" and "research groups" are used interchangeably. Research groups are operationally defined in this study as "communication groups" in the terminology of

*Because of such heterogeneity, it would be more appropriate to talk in plural about "research communities."

communication network analysis. They may be interconnected with each other through some of their respective members, who, while being group members, perform the role of bridges between groups. However, the particular role which is often salient in linking disparate groups is that of "liaison." These individuals in research networks serve as natural research leaders; they are informal coordinators, who intensively engage in interchanges with members of several "invisible colleges," mediate new findings, opportunities, and opinions between groups, and also bind separate groups to a common paradigm. Liaisons in association with influential members of research groups exercise leadership and guidance in their research network, providing orientations in the selection of research problems and techniques, and sanctioning research work with competent assessments, recognition, and rewards.

The rest of the participants constitute a role designated in communication network analysis by the term "others." They are those people who actively engage in research interchanges but remain "independent," and those who are in the process of forming new groups or entering already established groups.

The remaining part of the network is constituted by non-participants; these range from total isolation to a limited contact with participants or with other non-participants. Four different roles among non-participants are: isolates type one, isolates type two, dyad members, and tree nodes (the corresponding definitions are on p. 105).

To decipher network structure, data was processed by the Richards' computerized NEGOPY program (1975). Half of the participants are group members, and four persons perform the role of liaisons; on the other side, out of the 66 non-participants, 49 are tree nodes (Table 28).

Table 28. The distribution of the performance of network roles.

Role	N	Percentage
Participants	141	68.1
Group members	69	33.3
Liaisons	4	1.9
Others	68	32.9
Non-participants	66	31.9
Tree nodes	49	23.7
Dyads	4	1.9
Isolates type 2	3	1.4
Isolates type 1	10	4.9
TOTAL	207	100.0

The specificities of network structure are more clearly visualized when results are discriminated and mapped in reference to particular research groups (Table 29 and Figures 9-30). Twenty-two* invisible colleges were identified. Most of them are specialized: seven in bean research, six in tropical pastures, two in rice, and one in cassava. The other six groups combine researchers of different fields: four groups are integrated by rice and bean researchers, and two are composed of cassava and bean researchers. The size of research groups varies between three and fourteen persons; groups with three, four, or five people are most frequent (thirteen groups altogether).

*Groups are named with numbers from 1 to 25, as they were labeled by the NEGOPY program. This means that 3 clusters initially identified as groups did not meet one or more of the group criteria. The numbers used as group labels by the program were kept to facilitate the drawing of the maps, which is a relatively cumbersome task, given that NEGOPY does not plot these diagrams, but only gives numerical information.

Most research groups include professionals with and without CIAT training; two exceptions occur: one group in bean research (Figure 9) and the other group in tropical pastures (Figure 10), which consists exclusively of former CIAT trainees. Among the 135 persons in the twenty-two research groups, about one half are CIAT alumni. The group members without CIAT training include fifty-six researchers who work in Latin America, and ten professionals who work in other parts of the world, outside Latin America.

As for the transnational identities of group members, they split in two halves; eleven are entirely in-country groups, and eleven groups have members of various nationalities. However, in all twenty-two groups there is within-country dominance in the proportionate number of group members. The eleven groups with membership from various countries include five of the six tropical pastures groups (Figures 10-14), plus six groups integrated by rice researchers (Figures 15 and 16), rice and bean researchers (Figure 17), bean researchers (Figure 18), bean and cassava researchers (Figure 19), and cassava researchers (Figure 20). There is only one specialized group in cassava (Figure 20). There are two additional cassava trainees who are group members. The other two cassava trainees who are group members belong to groups numerically dominated by bean researchers (Figures 19 and 21). However, in one of these groups (Figure 19) the cassava researcher is the more central person in the group (identified by the number 53); the other four group members are bean researchers; and three of them are not former CIAT trainees. In another group the cassava researcher is the peripheral member (Figure 21, node number 2), but at the same time it is noticeable that this cassava researcher performs as a bridge helping to bind his

group (Group 9 in Figure 21) to a tropical pastures group (Group 14 in Figure 13).

Organizational affiliation and the country where members of research groups are currently working are not factors selected as independent variables in this study. Nevertheless, a look at these maps immediately suggests that these factors, in addition to field of research, are among the most relevant traits in tracing the identities of members of invisible colleges in the population of this study.

Twelve Latin American countries have representation in these twenty-two research groups: Bolivia, Brazil, Colombia, Costa Rica, Chile, Ecuador, Honduras, Mexico, Nicaragua, Paraguay, Peru, and Venezuela; there are no group members from the Caribbean countries. Eight countries in the rest of the world, outside the region, also have participants in these twenty-two invisible colleges: Japan, the Philippines, India, Syria, the Netherlands, Denmark, England, and the U.S.A.

The eleven within-country groups are: two in Brazil (Figures 22 and 23), three in Colombia (Figures 21, 24, and 25), one in Costa Rica (Figure 26), two in Ecuador (Figures 27 and 28), one in Honduras (Figure 9), one in Mexico (Figure 29), and one in Venezuela (Figure 30).

With the exception of three groups, invisible colleges normally include persons from differing research organizations. These three groups are: one in ICA, Colombia (Figure 24), one in INIAP, Ecuador (Figure 27), and one in the Ministry of Natural Resources of Honduras (Figure 9). All members of these three groups are bean researchers.

The distribution of organizational affiliation of the 135 persons who compose the 22 research groups identified by this study is

presented in Table 29. About half of them work for national agricultural research institutes (this type of institute is briefly described on p. 29). Almost one third belong to universities and governmental agencies; two of those are U.S. universities, and the rest are universities of seven Latin American countries: Brazil, Colombia, Chile, Mexico, Peru, Puerto Rico, abd Venezuela. Researchers from four international centers--CIAT, IRRI, ICRISAT, and ICARDA--participate in these groups; however, it is called to the attention of readers that the other two international centers working the region--CIMMYT and CIP--are not represented in these invisible colleges. Finally, about one in every nine group members is affiliated with a country-based or an international private organization.

Table 29. Members of the 22 research groups by type of organizational affiliation.

Organization	Number	Percentage
National research institute	69	51.1
University	22	16.3
Other governmental agency	20	14.8
International center	12	8.9
In-country private organization	9	6.7
International private organization	3	2.2
TOTAL	135	100.0

By relationship to the identities of group members, the relevant interplay of fields of research, countries where currently working, and organizational affiliation may be realized in describing one of these invisible colleges, e.g., group 7 (Figure 19). This group is integrated

by five researchers. Four are bean researchers. The other one is a cassava trainee who has been studying the crop association bean-cassava. The group includes four nationalities and four organizational affiliations: two people are from the Universidad Tecnica del Piura, in Perú; one is from ICA, the Colombian institute of agricultural research; another from FONAIAP, the Venezuelan national organization for agricultural research; and the last one is a researcher in a Japanese organization. This invisible college is connected with groups 14 (Figure 13) and 15 (Figure 18) through person number 54, who plays the role of liaison. This professional is a woman from Peru. She was trained at CIAT in cassava research. Group 7 is also bound to group 10 (Figure 15) by person number 697, a bean researcher. In addition, group 7 is connected by groups 19 (Figure 14) and 23 (Figure 28) by means of members of the corresponding groups who perform as bridges between these groups. Group 7 is described here as a matter of example, but not as typical of the research groups existing in this network; in fact, there are no typical groups; each one has its own characteristics. Some commonalities among them are mentioned elsewhere.

Participants in this research network are totally interconnected with each other. An all-encompassing picture of these inter-dependencies is presented in Figure 31 (p. 175). With the purpose of simplifying the visual representation, only groups and liaisons are shown in this map. Some clusters of groups by field of research can be recognized. Such is the case of groups 1, 11, 14, 19, and 20, composed of tropical pastures researchers. Specialized groups in rice, beans, and cassava are well interconnected wtih groups including researchers of two commodities--in some cases cassava and beans, in others, rice and beans.

The roles of liaisons are performed by four former CIAT trainees, four members of the staff of CIAT, and one member of the staff of INIA, in Mexico.

A profile of some personal characteristics of the segment of this analysis sample who are members of research groups follows. (Table 31, p. 176). They range between 24 and 55 years of age, similar to what occurs in the rest of the population; however, frequencies in the ages between 24 and 34 years are higher for group members than for the rest of the population. These frequencies characterize sample group members as relatively young researchers. Group members are, with one exception, males. The proportions between single and married people are the same in this sub-sample as in the population. As for education, there is a slight tendency for practitioners holding higher formal degrees to be group members. There is a group member whose education is under the B.S. level.

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*The text continues after the presentation of Table 31 and Figures 9 through 30, on page 177).

Table 30. Research groups identified through the network analysis. Research groups are characterized in this table in terms of group size, number of former trainees within groups specified by training content, and country of origin of group members.

GROUP 1

Size: 5 persons.
Former trainees: Tropical pastures, 3.
Countries: Ecuador, 4; U.S.A., 1.

GROUP 2

Size: 7 persons.
Former trainees: Cassava, 3.
Countries: Brazil, 6; England CIAT), 1.

GROUP 3

Size: 4 persons.
Former trainees: Beans, 4.
Country: Honduras, 4.

GROUP 4

Size: 8 persons.
Former trainees: Beans, 5; rice, 1.
Country: Costa Rica, 8.

GROUP 5

Size: 3 persons.
Former trainees: Tropical pastures, 1.
Countries: Mexico, 2; Paraguay, 1.

GROUP 6

Size: 13 persons.
Former trainees: Beans, 7; rice, 1.
Country: Brazil, 13.

GROUP 7

Size: 5 persons.
Former trainees: Cassava, 1; beans, 1.
Countries: Peru, 2; Venezuela, 1; Colombia, 1; Japan, 1.

GROUP 8

Size: 6 persons.
Former trainees: Beans, 3.
Country: Brazil, 6.

Table 30. (continued).

GROUP 9

Size: e persons.
Former trainees: Cassava, 1; beans, 2.
Country: Colombia, 4.

GROUP 10

Size: 3 persons.
Former trainees: Rice, 2.
Country: Perú, 3.

GROUP 11

Size: 5 persons.
Former trainees: Tropical pastures, 3.
Countries: Venezuela, 4; Puerto Rico, 1.

GROUP 12

Size: 4 persons.
Former trainees: Beans, 3.
Country: Ecuador, 4.

GROUP 13

Size: 14 persons.
Former trainees: Beans, 6; rice, 1.
Countries: Chile, 11; Colombia (CIAT), 1; India, 1; Syria, 1.

GROUP 14

Size: 5 persons.
Former trainees: Tropical pastures, 3.
Countries: Colombia, 3; Colombia (CIAT), 1; Denmark, 1.

GROUP 15

Size: 3 persons.
Former trainees: Beans, 2.
Countries: Peru, 2; Netherlands, 1.

GROUP 16

Size: 3 persons.
Former trainees: Beans, 1; rice, 1.
Country: Colombia, 3.

Table 30. (continued)

GROUP 17

Size: 7 persons.
Former trainees: Rice, 4.
Countries: México, 6; Philippines, 1.

GROUP 18

Empty.

GROUP 19

Size: 10 persons.
Former trainees: Tropical pastures, 4.
Countries: Bolivia, 1; Colombia, 2; Colombia (CIAT), 2; Perú, 1; Perú (CIAT), 2; U.S.A., 1; U.S.A., (CIAT), 1.

GROUP 20

Size: 3 persons.
Former trainees: Tropical pastures, 3.
Countries: Brazil, 1; Nicaragua, 1; Venezuela, 1.

GROUP 21

Empty.

GROUP 22

Empty.

GROUP 23

Size: 8 persons.
Former trainees: Beans, 5.
Country: Ecuador, 8.

GROUP 24

Size: 4 persons.
Former trainees: Beans, 2.
Country: Colombia, 4.

GROUP 25

Size: 11 persons.
Former trainees: Beans, 5.
Country: Mexico, 11.

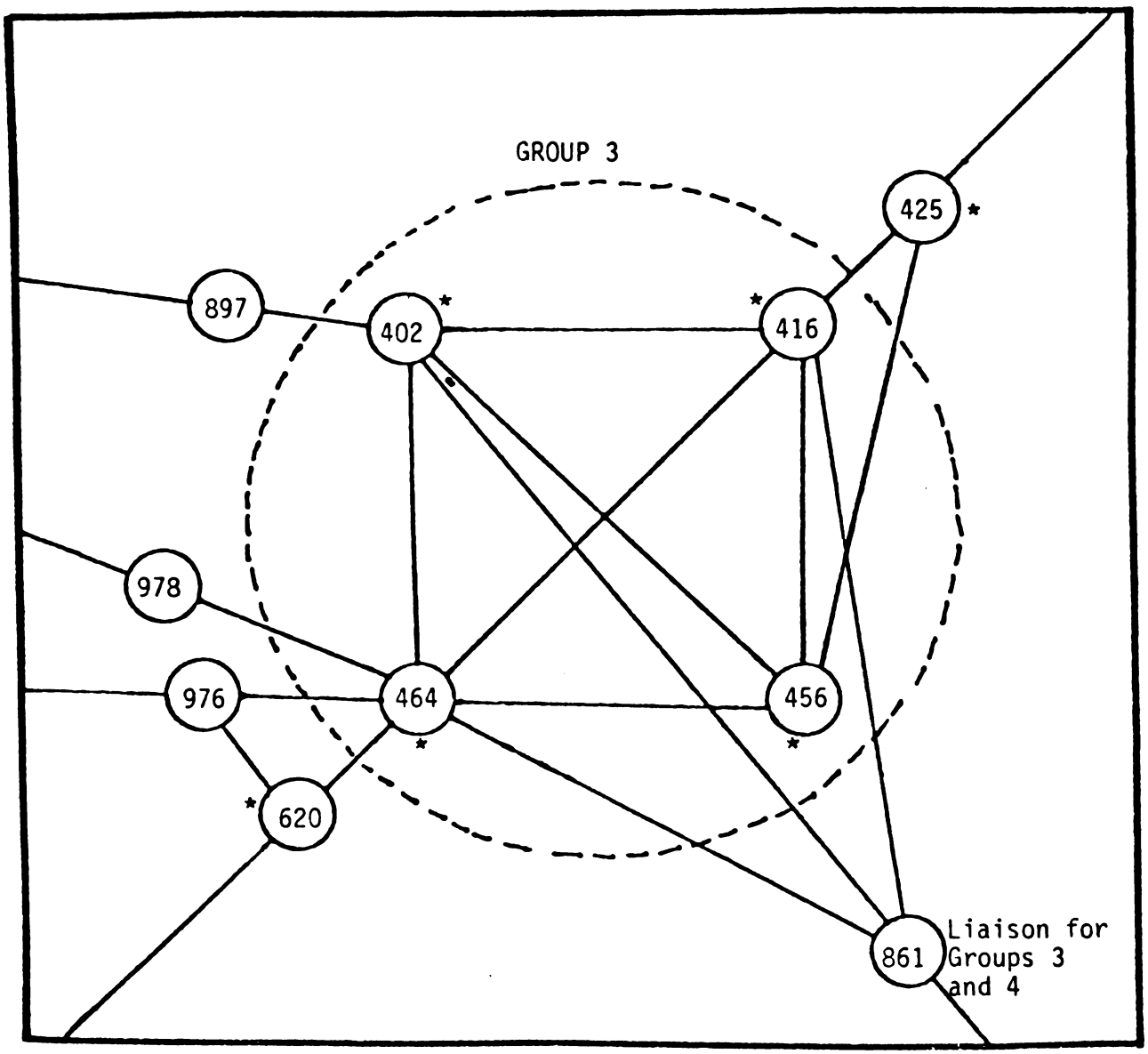


Figure 9. Group number 3, integrated by bean researchers. Organizational affiliations of groups members are:

*402 = Min. R. N., Honduras
*416 = Min. R. N., Honduras
*456 = Min. Rec. Nat., Honduras
*462 = Min. Rec. Nat., Honduras

* = Former CIAT trainee

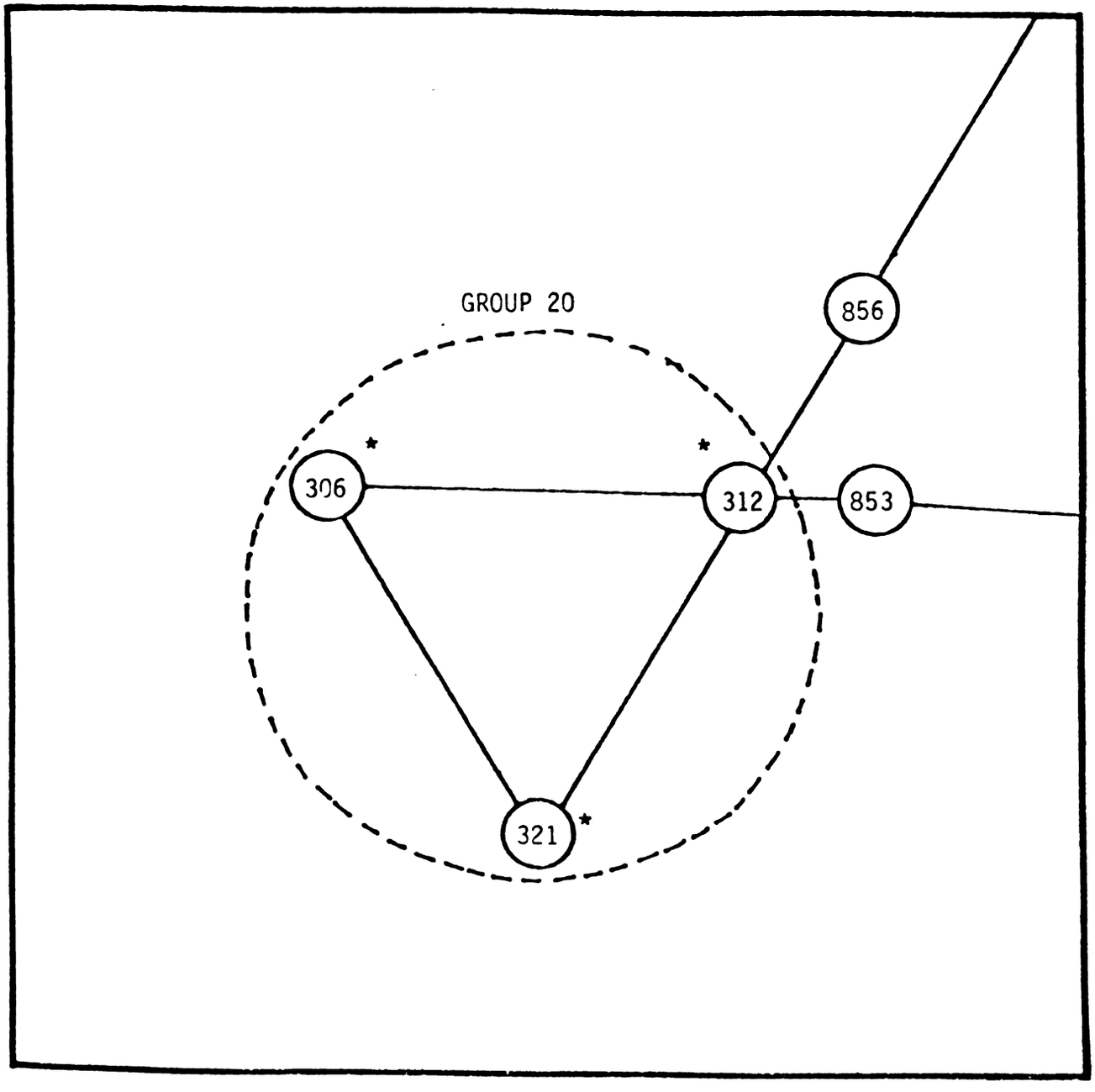


Figure 10. Group number 20, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*306 = FONAIAP, Venezuela
*312 = EMGOPA, Brazil
*321 = INTA, Nicaragua

* = Former CIAT trainee

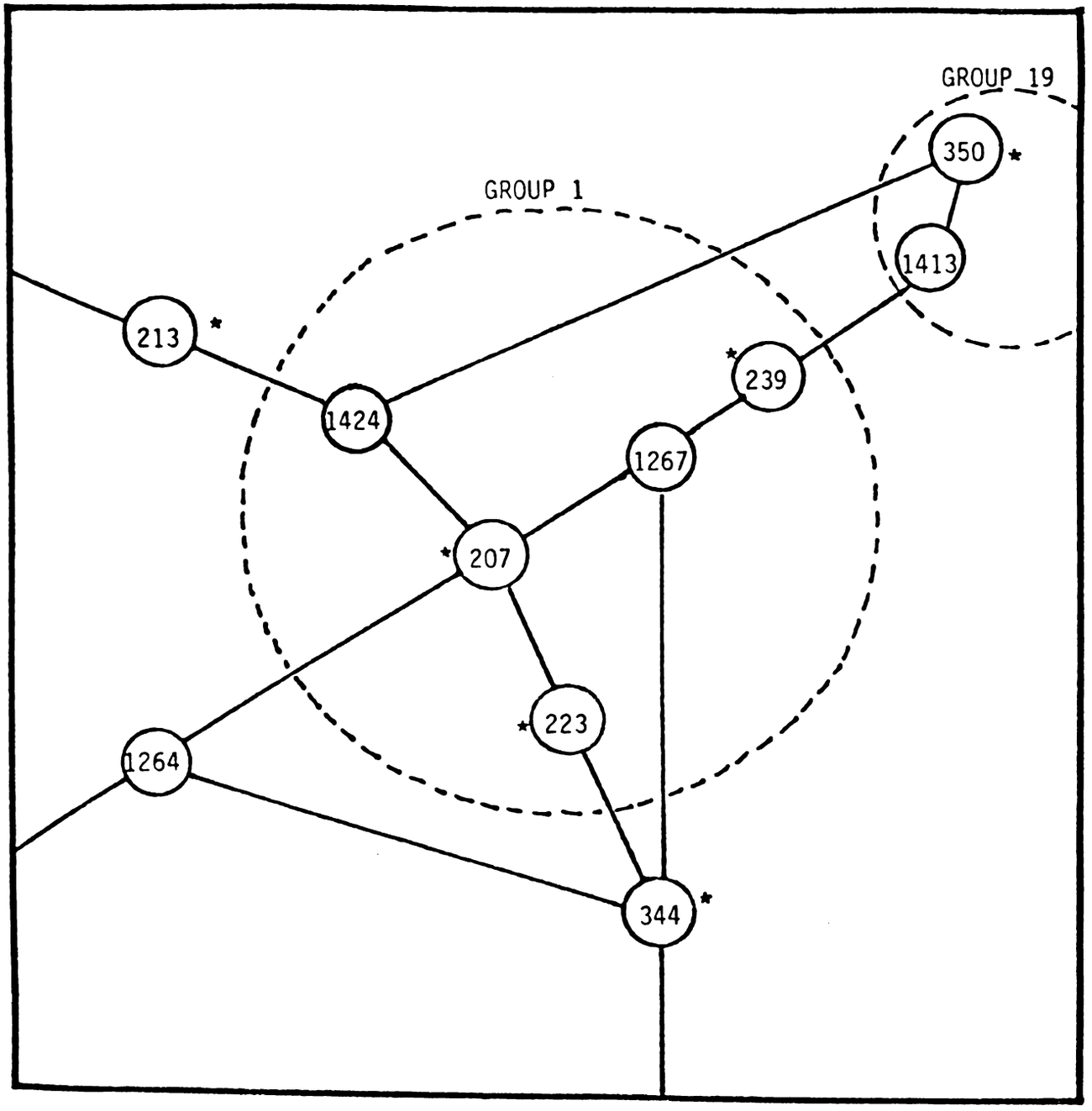


Figure 11. Group number 1, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*207 - INIAP, Ecuador
*223 - INIAP, Ecuador
*239 - INIAP, Ecuador
1267 - U. of Florida; U.S.A.
1424 - U. Catolica, Chile

* = Former CIAT trainee

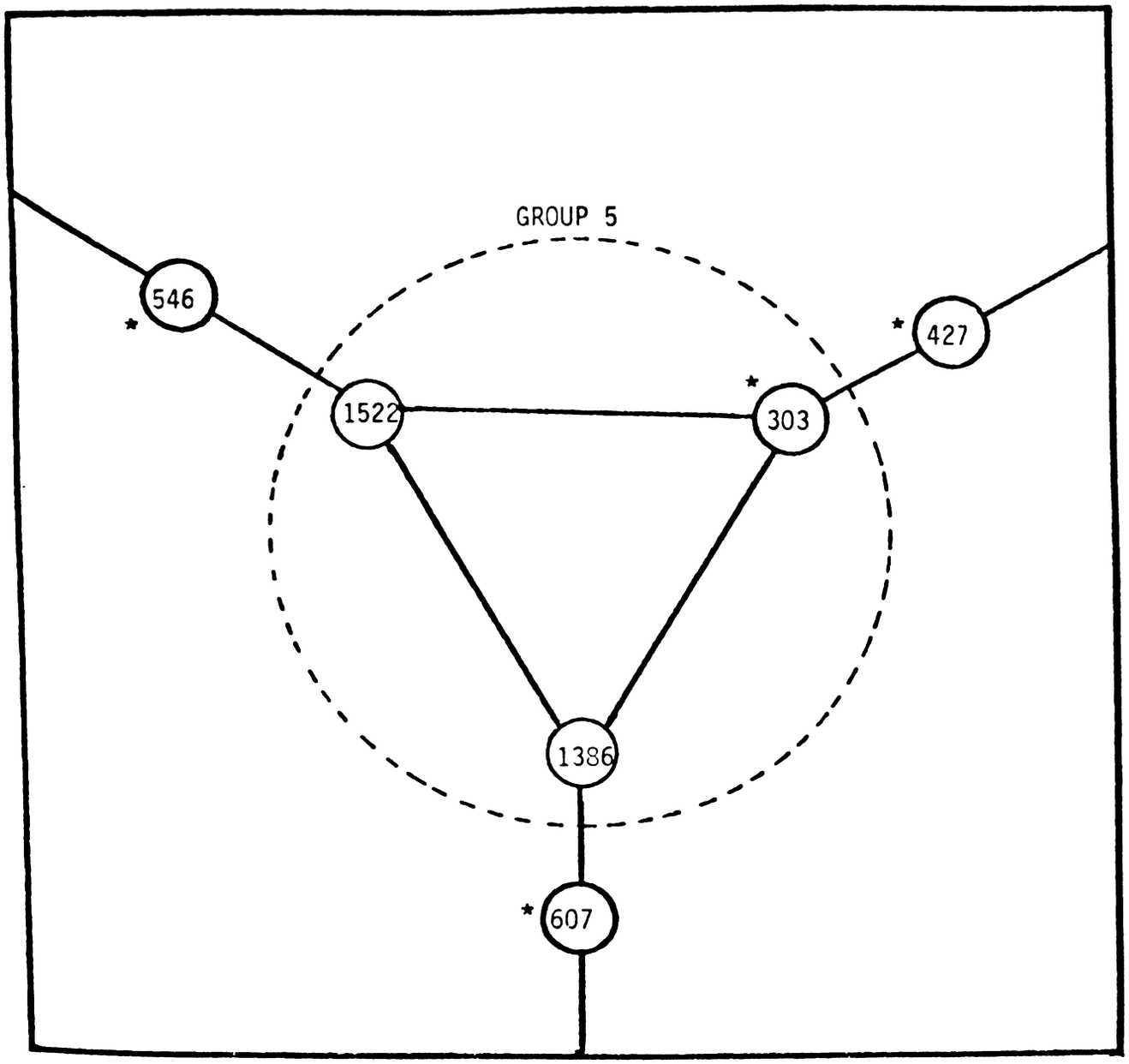


Figure 12. Group number 5, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*303 = Colegio Superior de Ag. Tropical, Tabasco, Mexico
1386 = Colegio Superior de Ag. Tropical, Tabasco, Mexico
1522 = Ministerio de Agricultura y Ganaderia, Paraguay

* = Former CIAT trainee

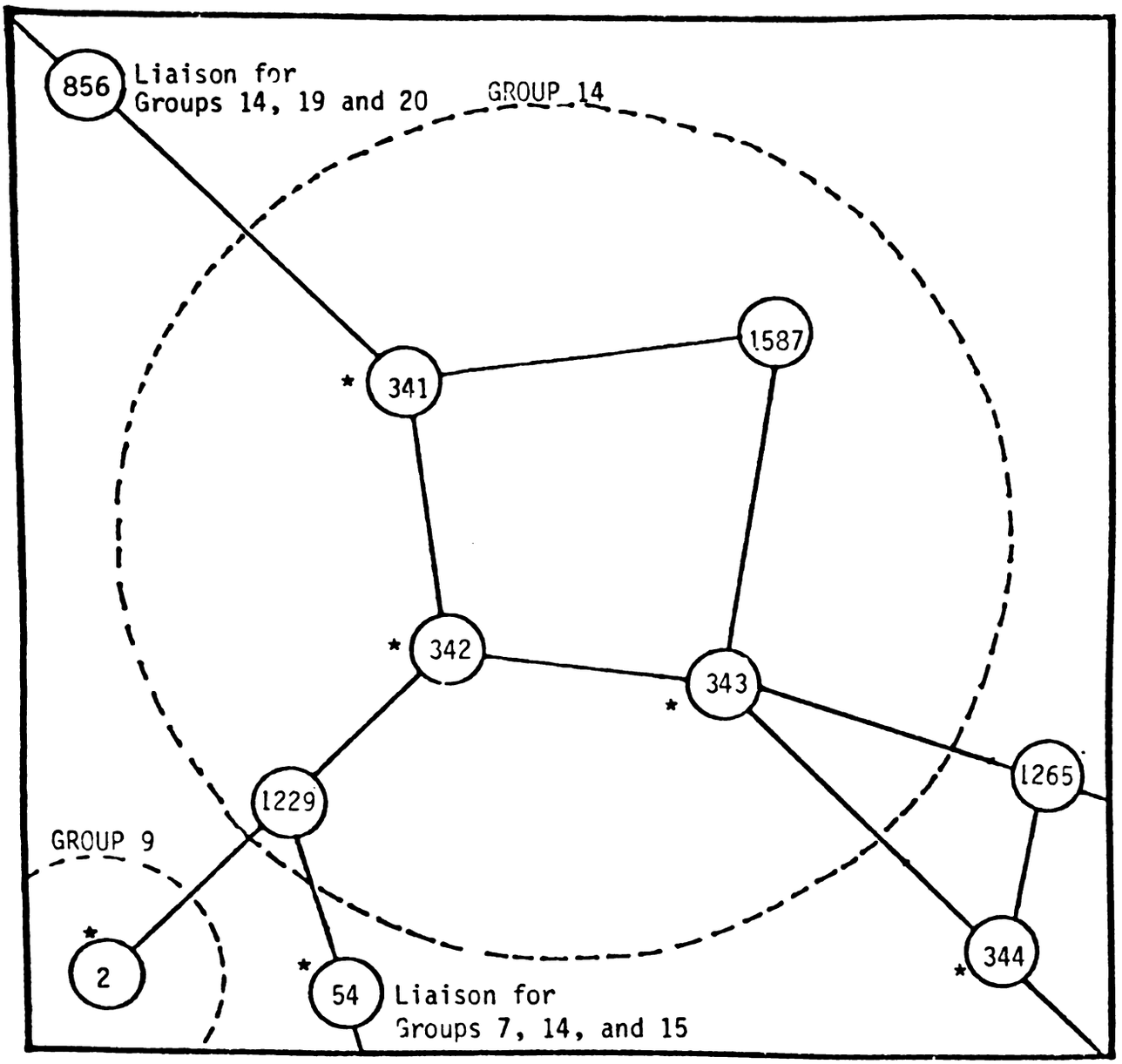


Figure 13. Group number 14, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*341 = FG, Valle, Colombia
*342 = SDF, Valle, Colombia
*343 = FG, Putumayo, Colombia
1229 = D. I. S. P., Denmark
1587 = CIAT, Colombia

* = Former CIAT trainee

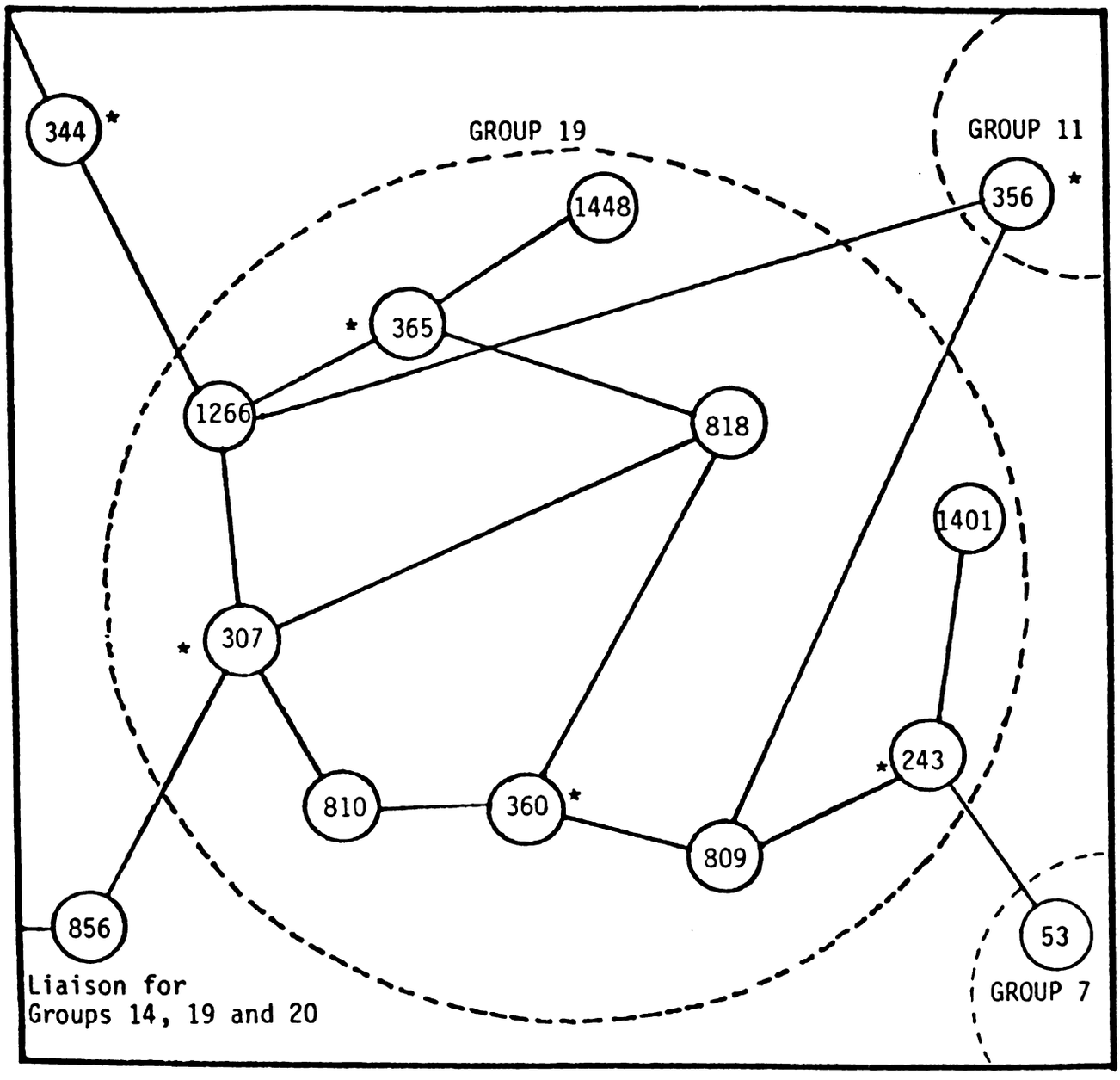


Figure 14. Group number 19, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*243 = CIAT, Colombia	810 = CIAT, Colombia
*307 = CIAT**, Bolivia	818 = North Carolina U., U.S.A.
*360 = CIAT, Colombia	1266 = CIAT, Colombia
*365 = INIA, Peru	1401 = CIAT, Colombia
809 = CIAT, Colombia	1448 = IVITA, Peru

* = Former CIAT trainee
** = This is a national organization, different from CIAT, Colombia, which is international.

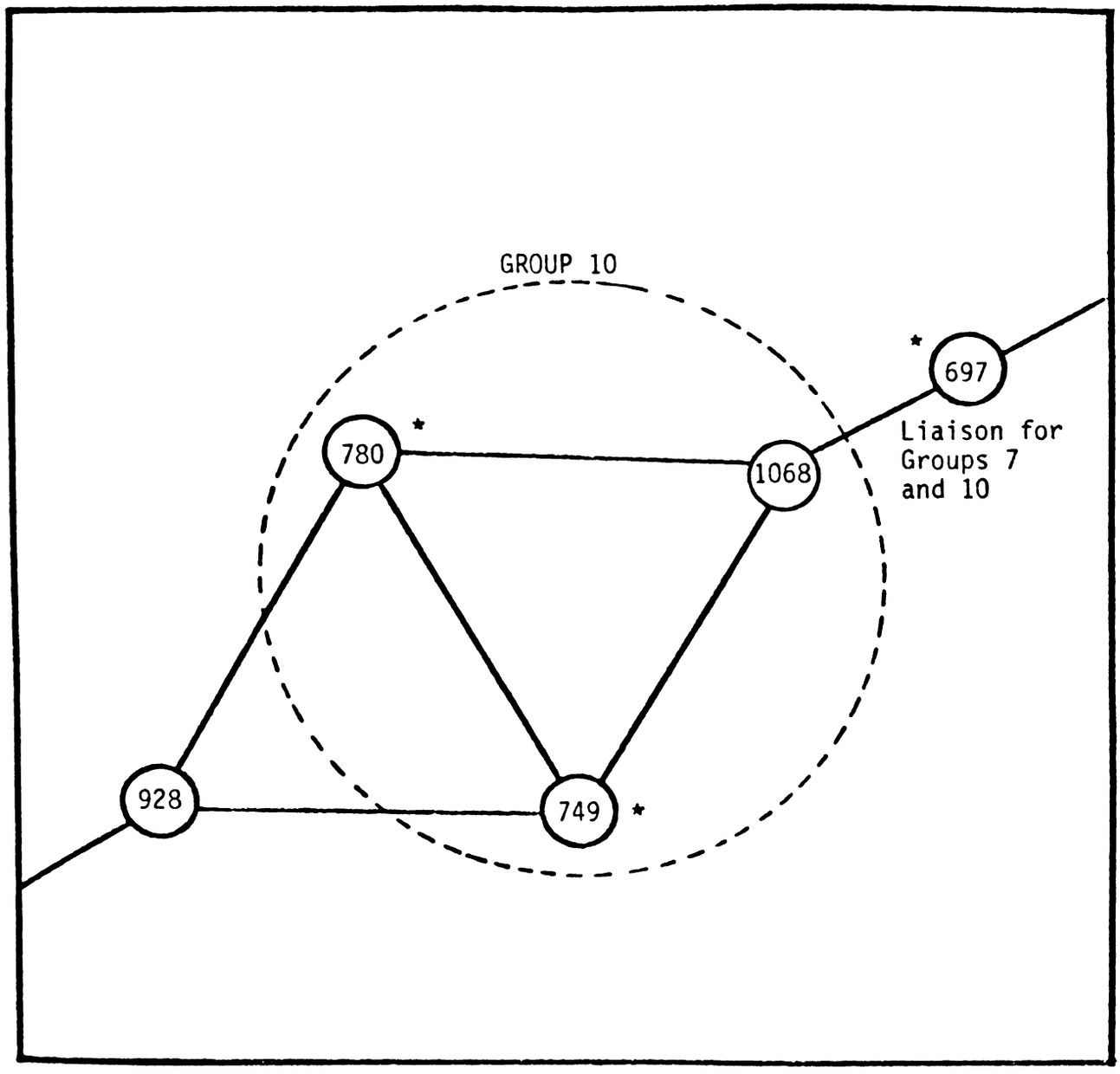


Figure 15. Group number 10, integrated by rice researchers. Organizational affiliations of group members are:

*749 = ACARPA, Brazil
*780 = INIA, Peru
1068 = CIAG-Norte, Peru

* = Former CIAT trainee

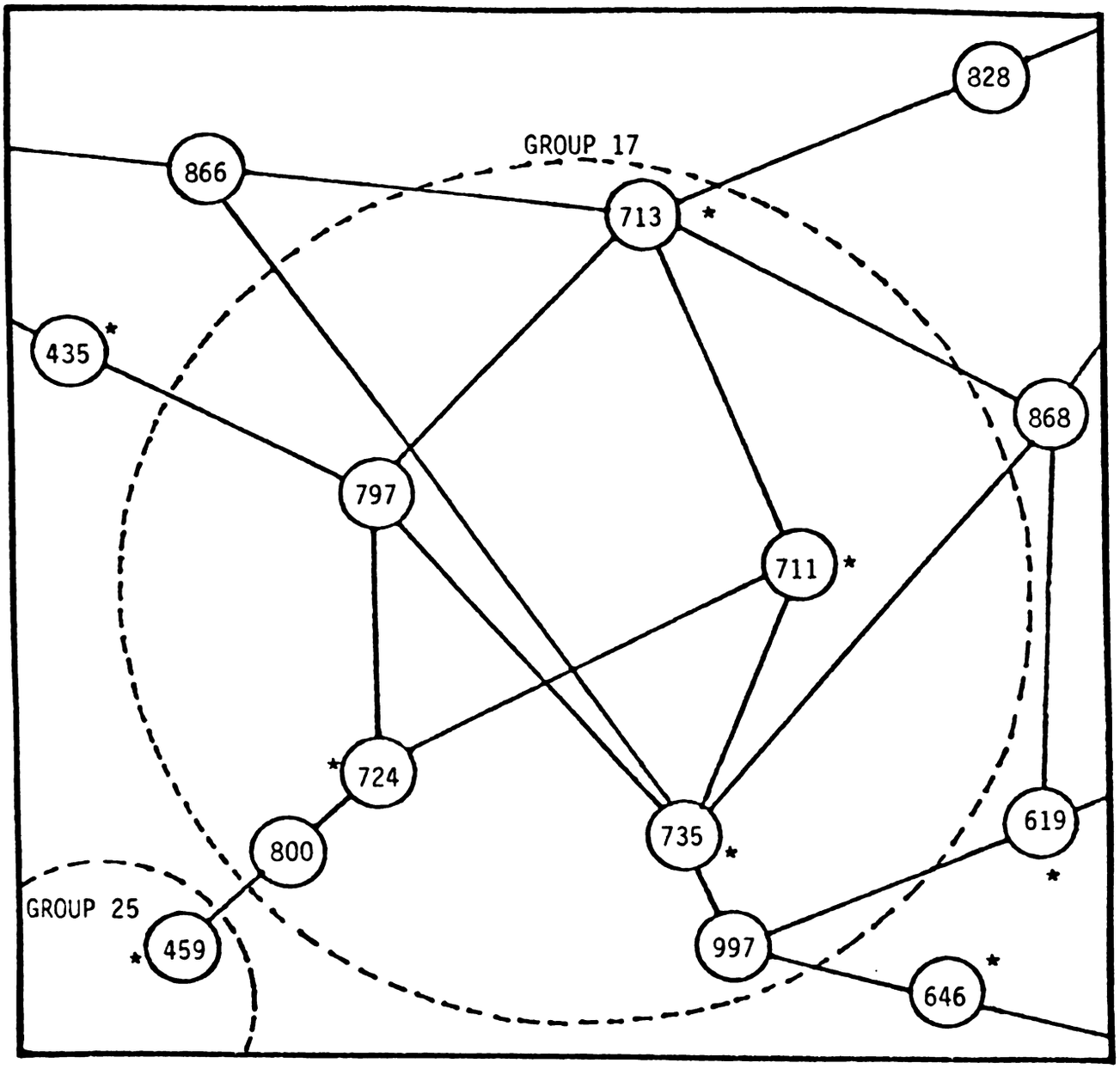


Figure 16. Group number 17, integrated by rice researchers. Organizational affiliations of group members are:

*711 = INIA, Mexico
*713 = INIA, Mexico
*724 = INIA, Mexico
*735 = INIA, Mexico
797 = INIA, Mexico
800 = Col. Post. Chapingo, Mexico
997 = IRRI, Philippines

* = Former CIAT trainee

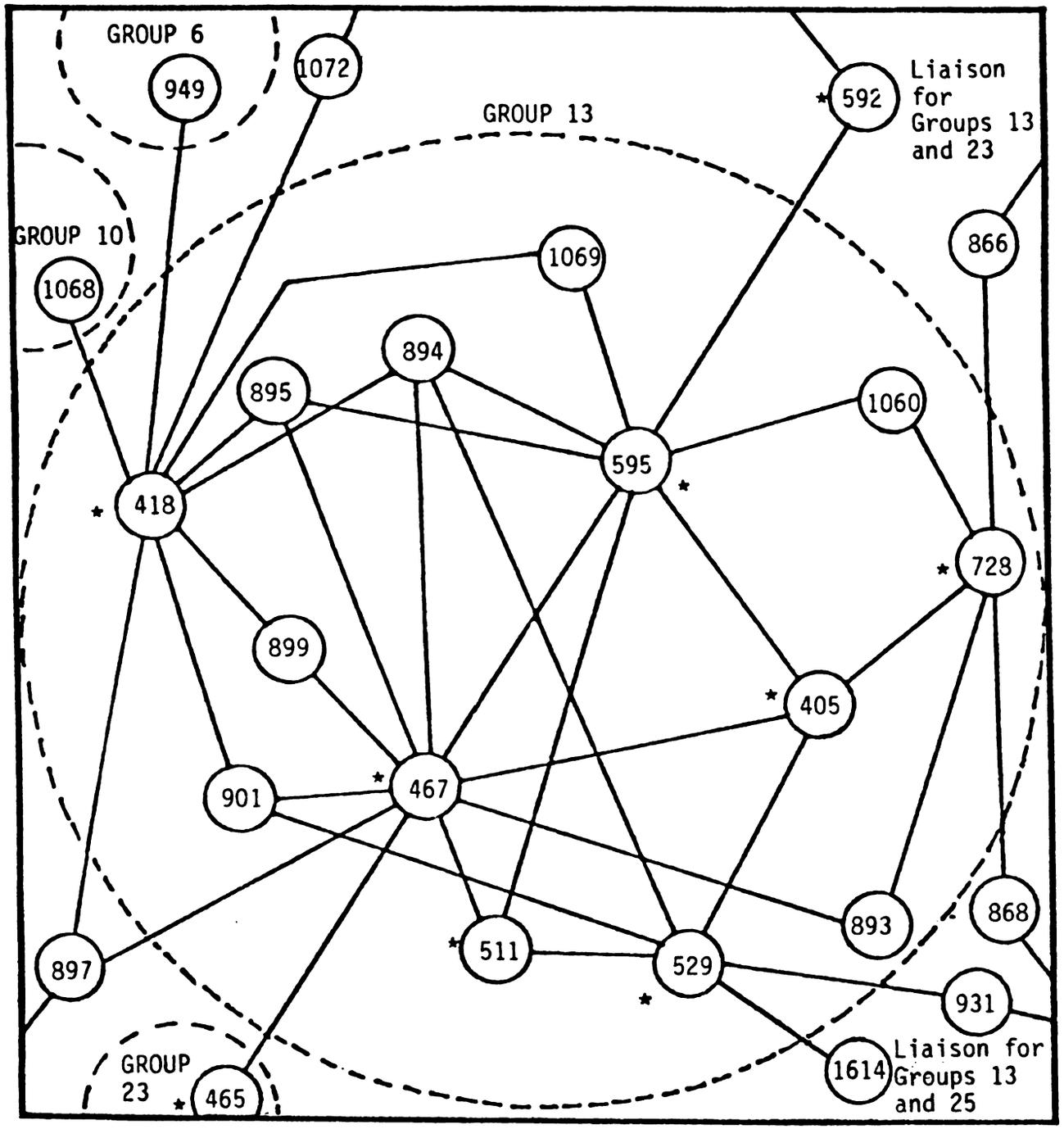


Figure 17. Group number 13, integrated by bean and rice researchers. Organizational affiliations of group members are:

*405 = INIA, Chile	893 = INIA, Chile
*418 = INIA, Chile	994 = INIA, Chile
*467 = INIA, Chile	995 = INIA, Chile
*511 = INIA, Chile	899 = ICRISAT, India
*529 = Soc. Nal. Ag., Chile	901 = ICARDA, Syria
*595 = INIA, Chile	960 = INIA, Chile
*728 = INIA, Chile	1069 = CIAT, Colombia

* = Former CIAT trainee

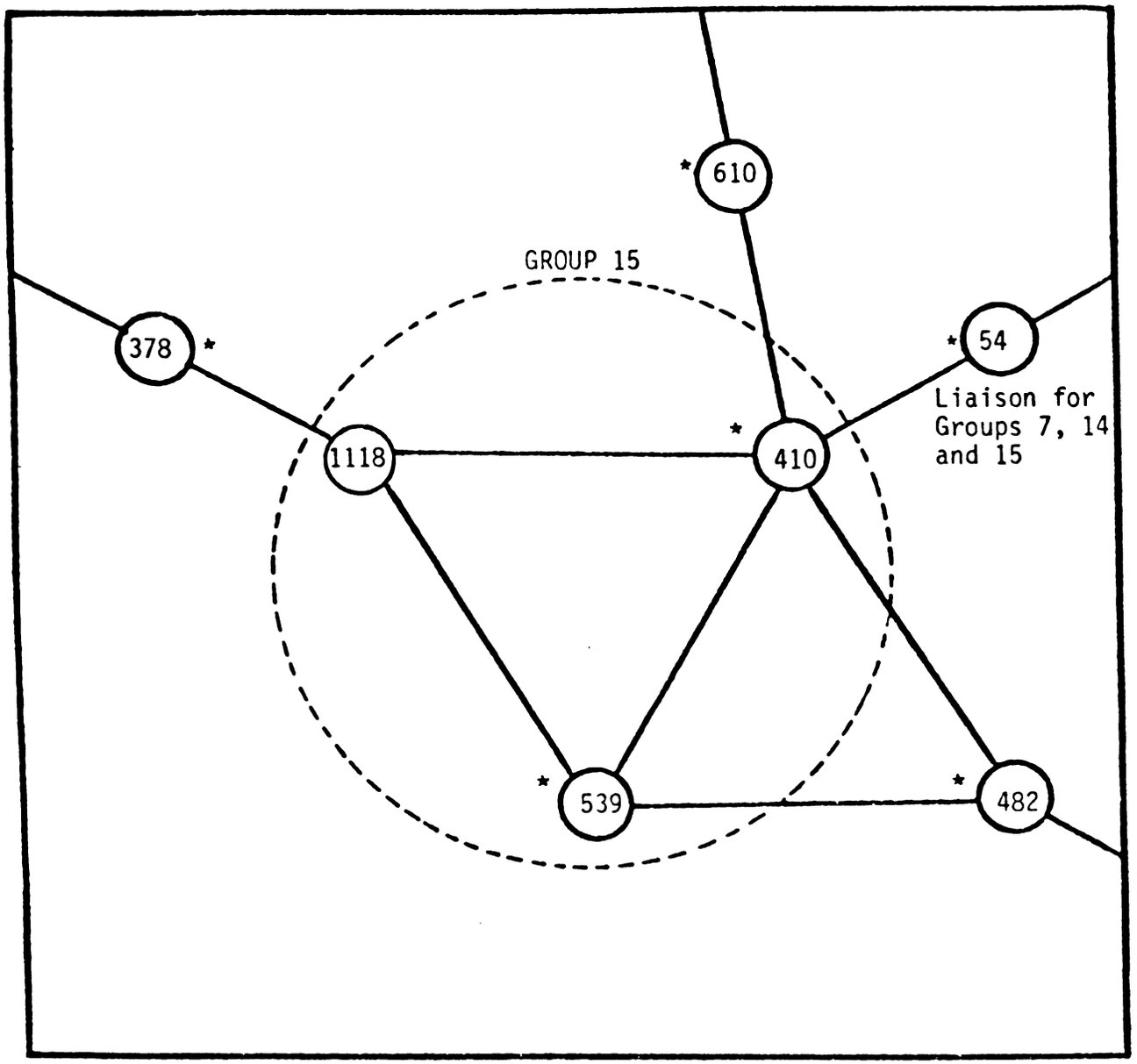


Figure 18. Group number 15, integrated by bean researchers. Organizational affiliations of group members are:

*410 = Universidad Agraria La Molina, Peru
*539 = Ministerio de Agricultura y Alimentacion, Peru
1118 = I. V. T., Netherlands

* = Former CIAT trainee

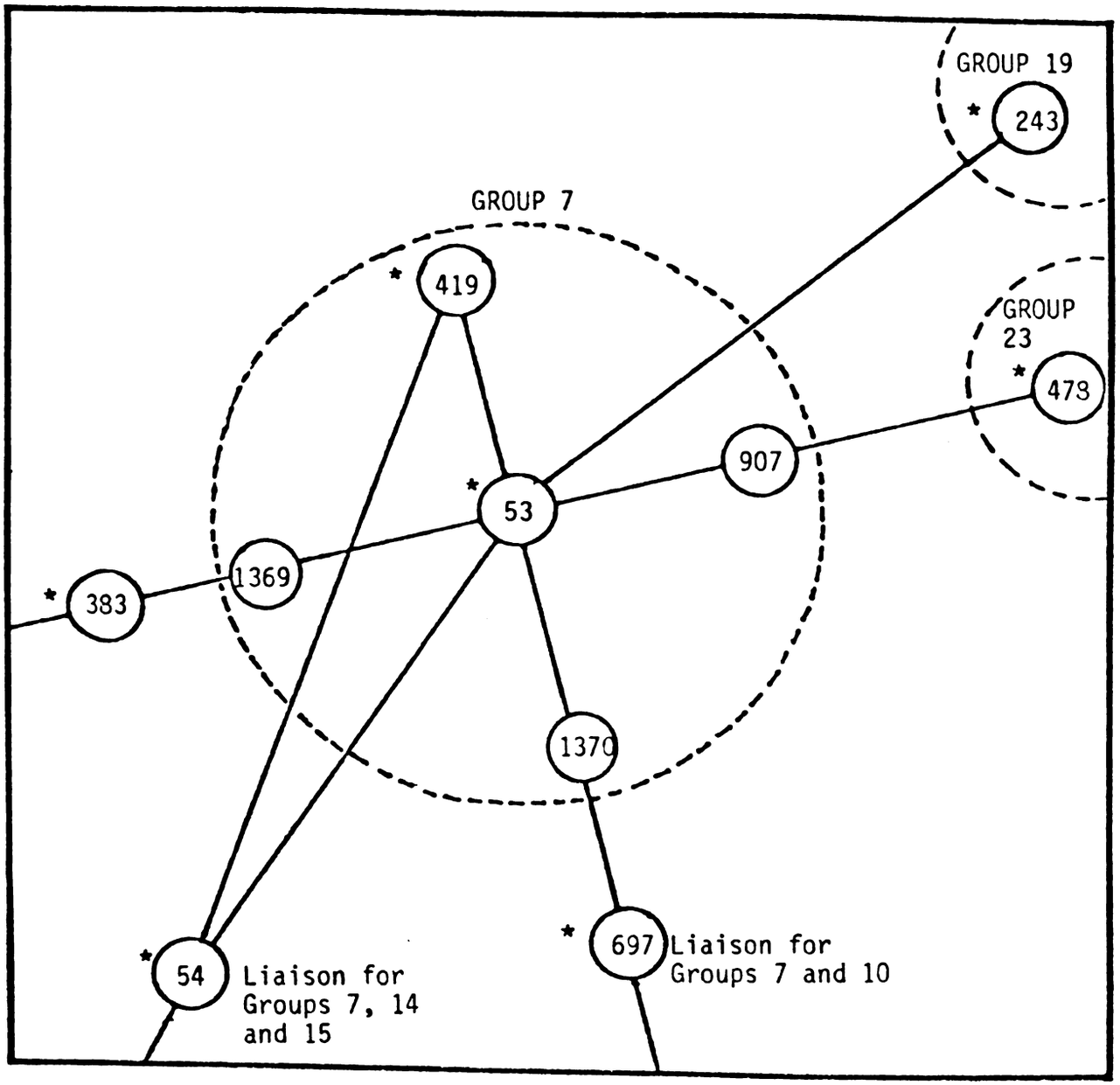


Figure 19. Group number 7, integrated by cassava and bean researchers. Organizational affiliations of group members are:

*53 = U. Tec. Piura, Peru
*419 = FONAIAP, Venezuela
907 = JICA, Japan
1369 = ICA, Colombia
1370 = Universidad Nacional Technica de Piura, Peru

* = Former CIAT trainee

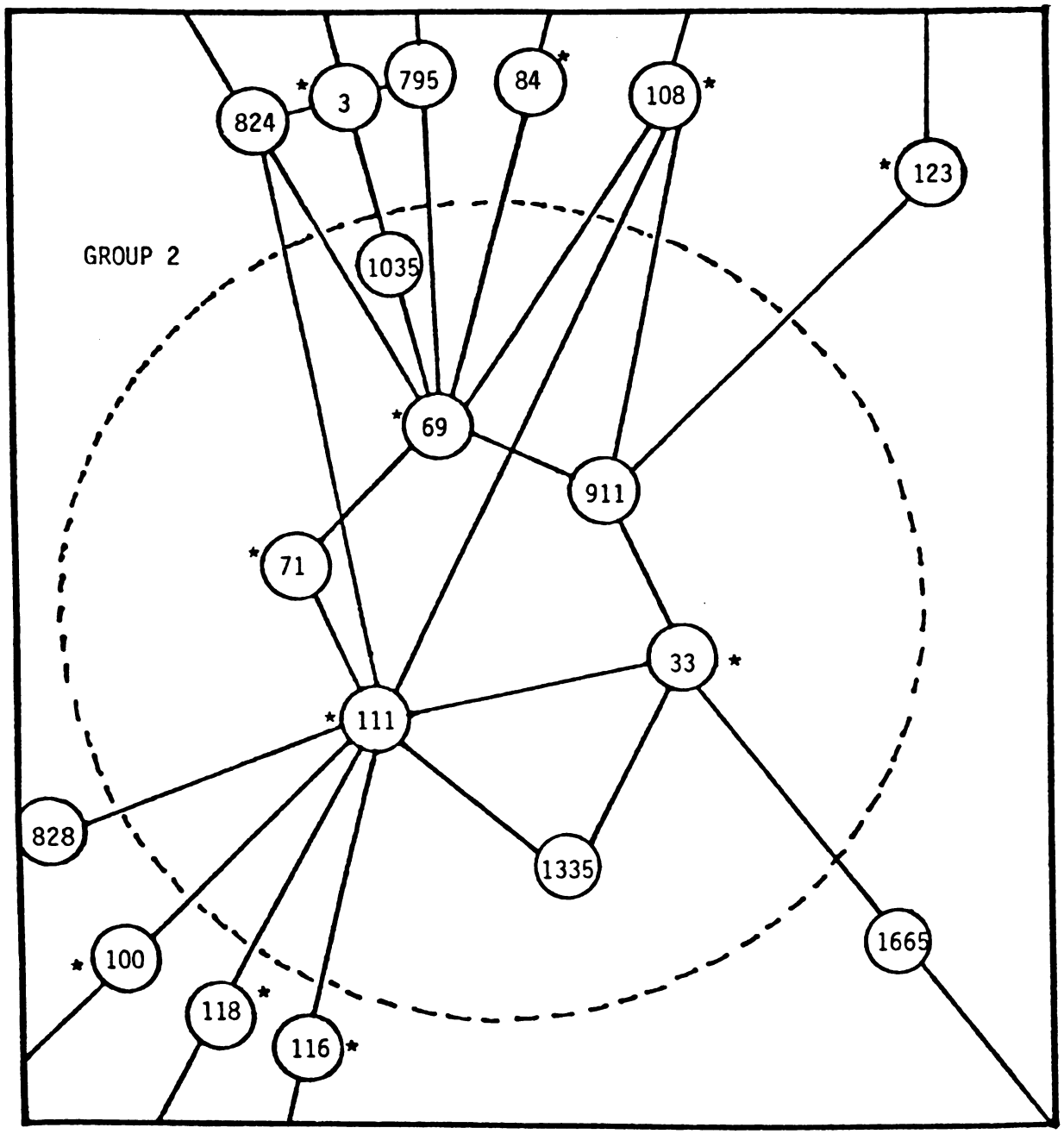


Figure 20. Group number 2, integrated by cassava researchers. Organizational affiliations of group members are:

*33 = EMCAPA, Brazil
*69 = EMBRAPA, Brazil
*71 = EMBRAPA, Brazil
*111 = Inst. Ag. Campinhas, Brazil
911 = EMBRATER, Brazil
1035 = CIAT, Colombia
1335 = Inst. Ag. Campinhas, Brazil

* = Former CIAT trainee

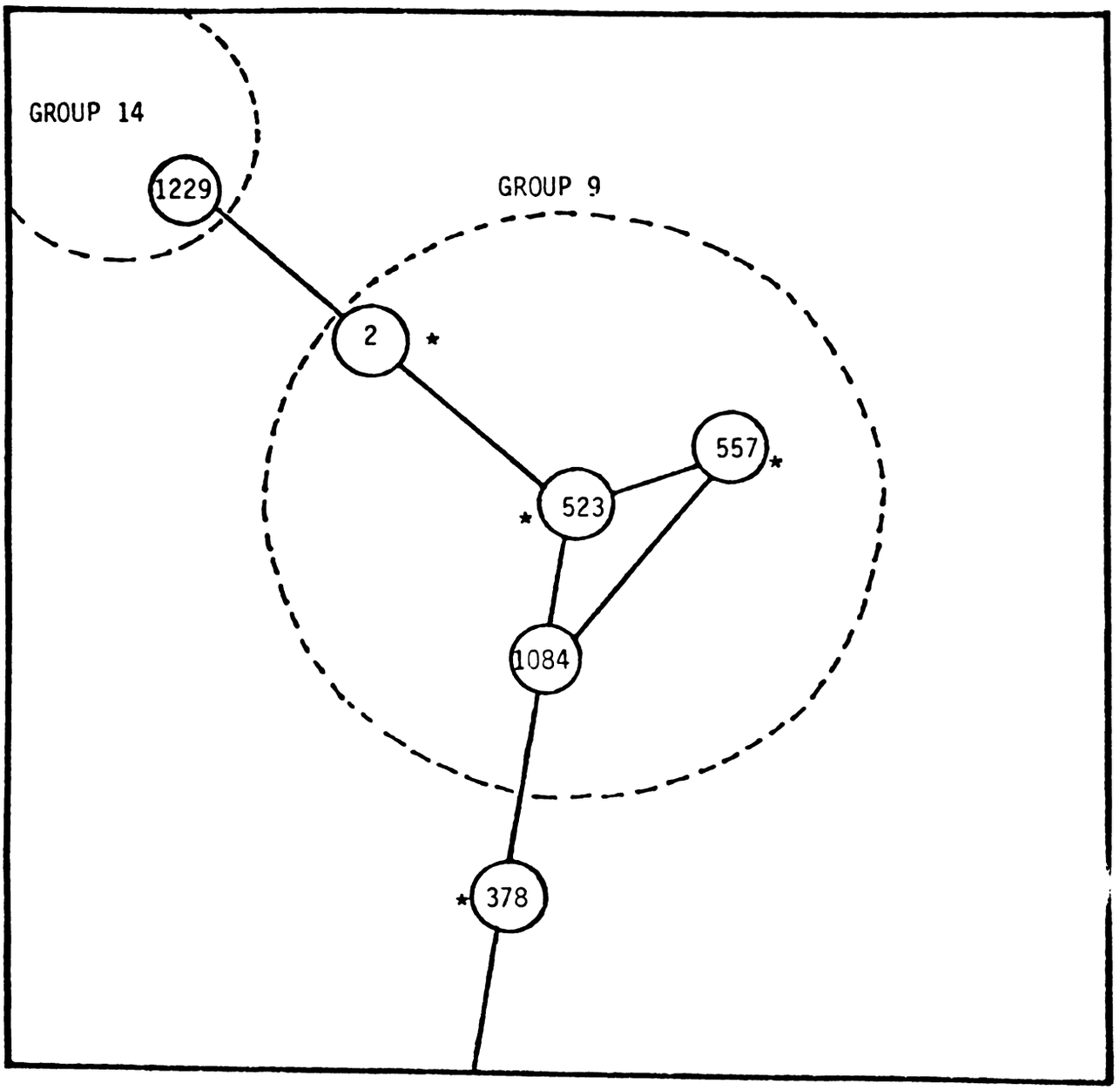


Figure 21. Group number 9, integrated by cassava and bean researchers. Organizational affiliations of group members are:

*2 = U. de Nariño, Colombia
*523 = ICA, Colombia
*557 = ICA, Colombia
1084 = Universidad de Nariño, Colombia

* = Former CIAT trainee

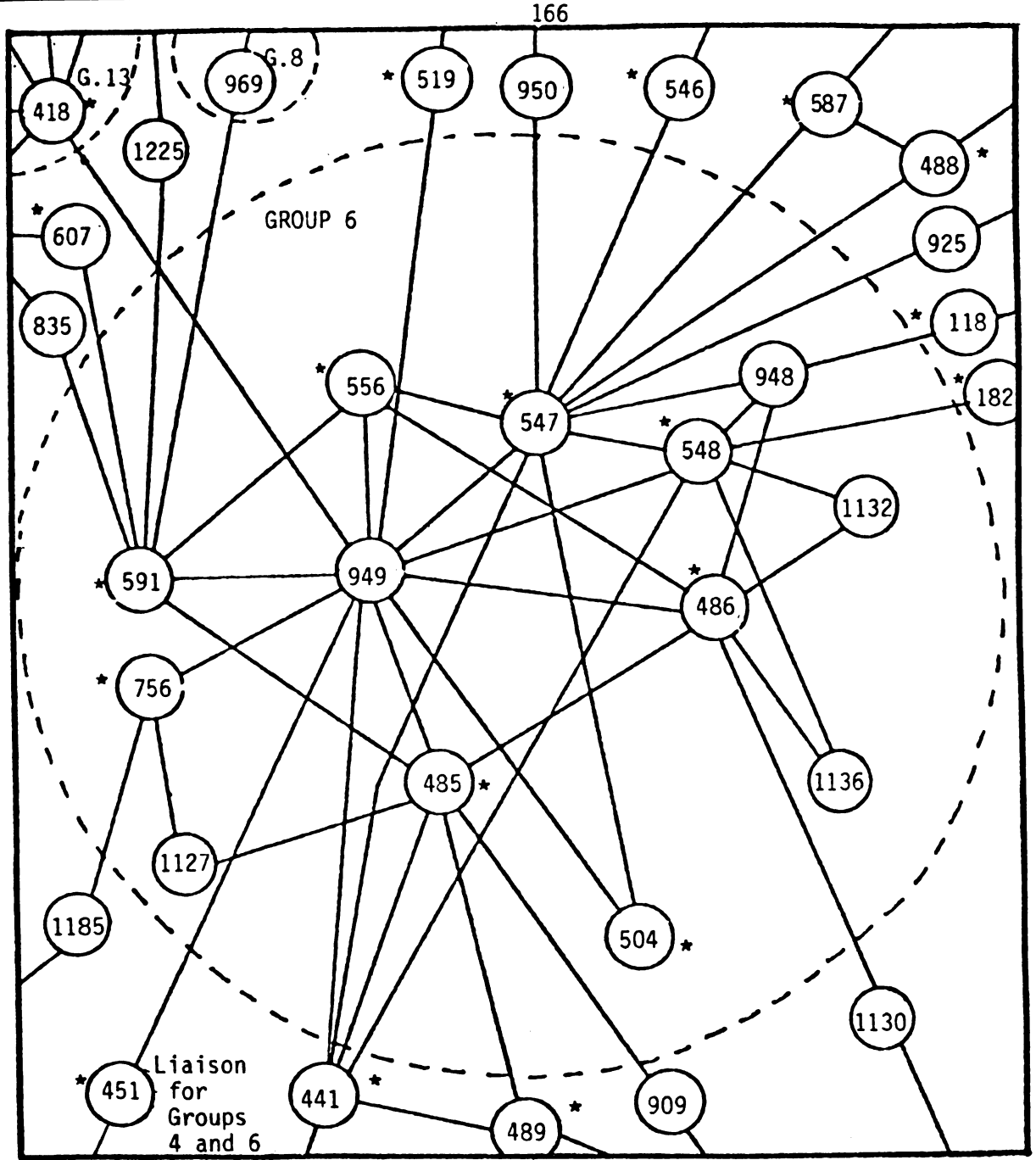


Figure 22. Group number 6, integrated by rice and bean researchers. Organizational affiliations of group members are:

*485 = EMCAPA, Brazil
*486 = EPA, Minas Gerais, Br.
*504 = ESA, Lavras, Brazil
*547 = EMBRAPA, Brazil
*548 = ESA, Lavras, Brazil
*556 = EPA, Minas Gerais, Br.
*591 = EMBRAPA, Brazil
*756 = EMATER, Brazil
948 = Emp. Pesq. Ag. Minas Gerais, Br.
949 = U. Federal do Vicosa, Brazil
1127 = PESAGRO, Rio do Janeiro, Brazil
1132 = Esc. Sup. Ag., Lavras, Brazil
1136 = Esc. Sup. Ag., Lavras, Brazil

* = Former CIAT trainee

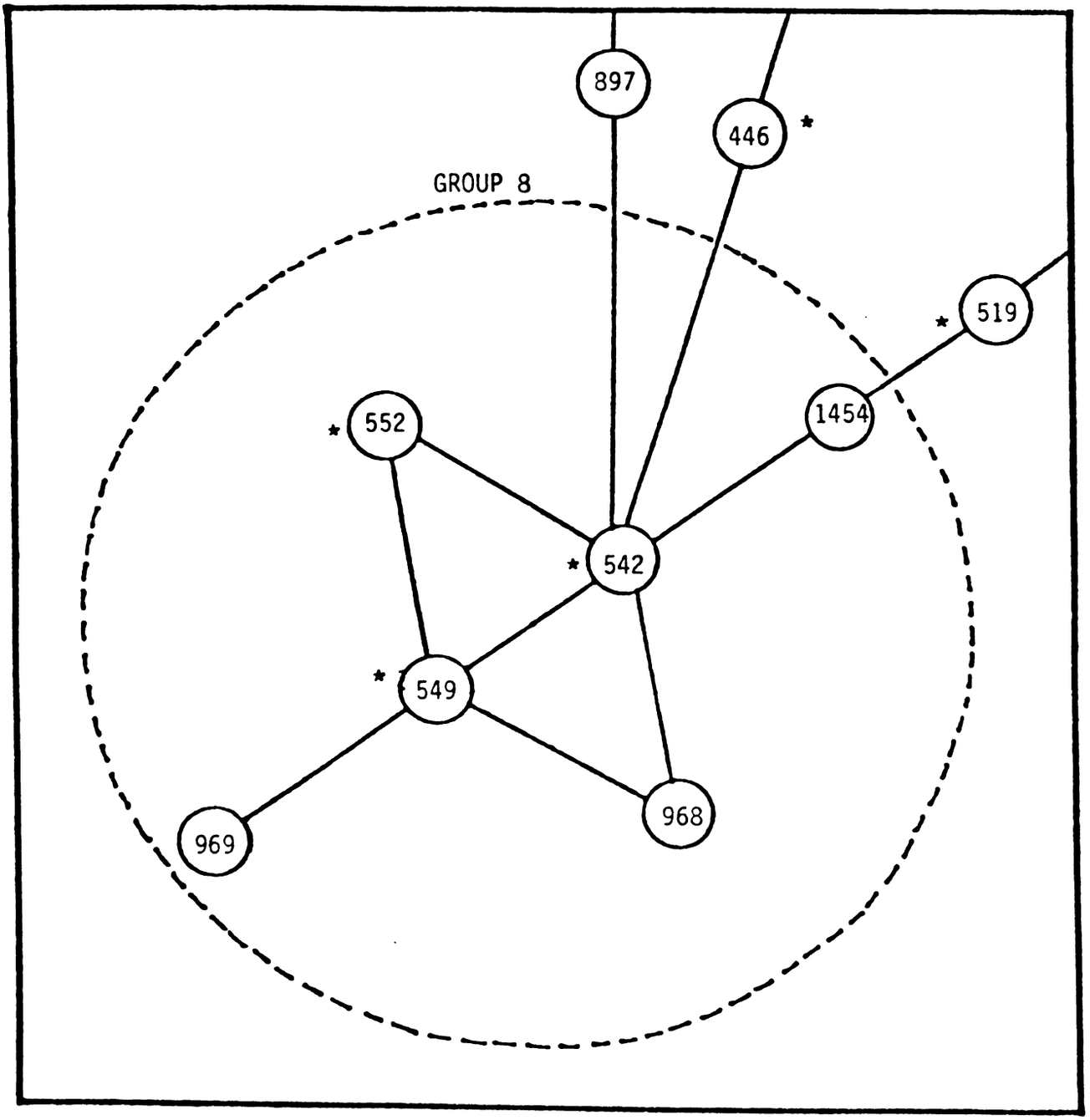


Figure 23. Group number 8, integrated by bean researchers. Organizational affiliations of group members are:

*542 = IAPAR, Brazil
*549 = ACARPA, Brazil
*552 = IAPAR, Brazil
968 = IAPAR, Brazil
969 = IAPAR, Brazil
1454 = IAPAR, Brazil

* = Former CIAT trainee

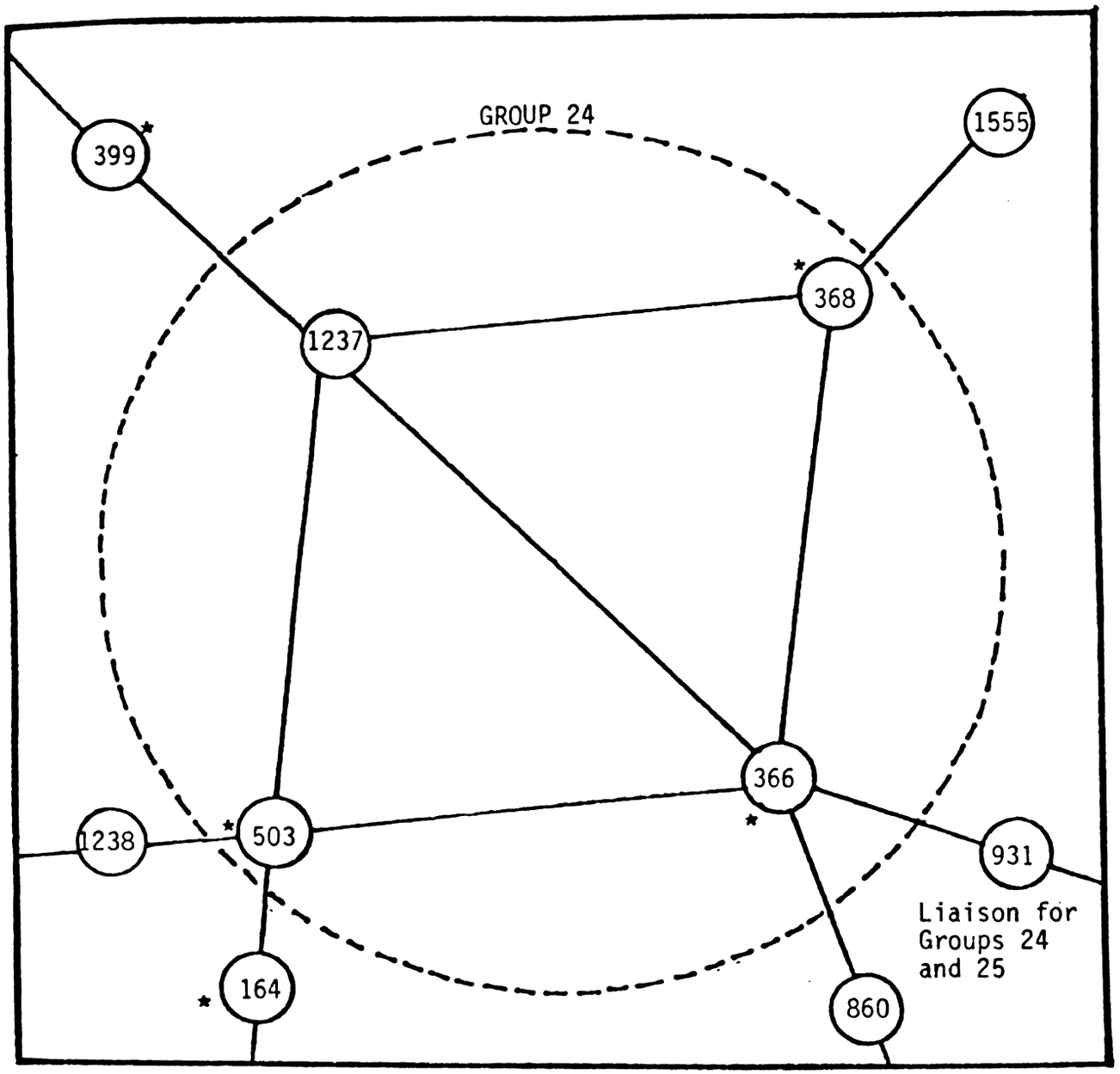


Figure 24. Group number 24, integrated by bean researchers. Organizational affiliations of group members are:

*366 = ICA, Colombia
*368 = ICA, Colombia
*503 = ICA, Colombia
1237 = ICA, Colombia
* = Former CIAT trainee

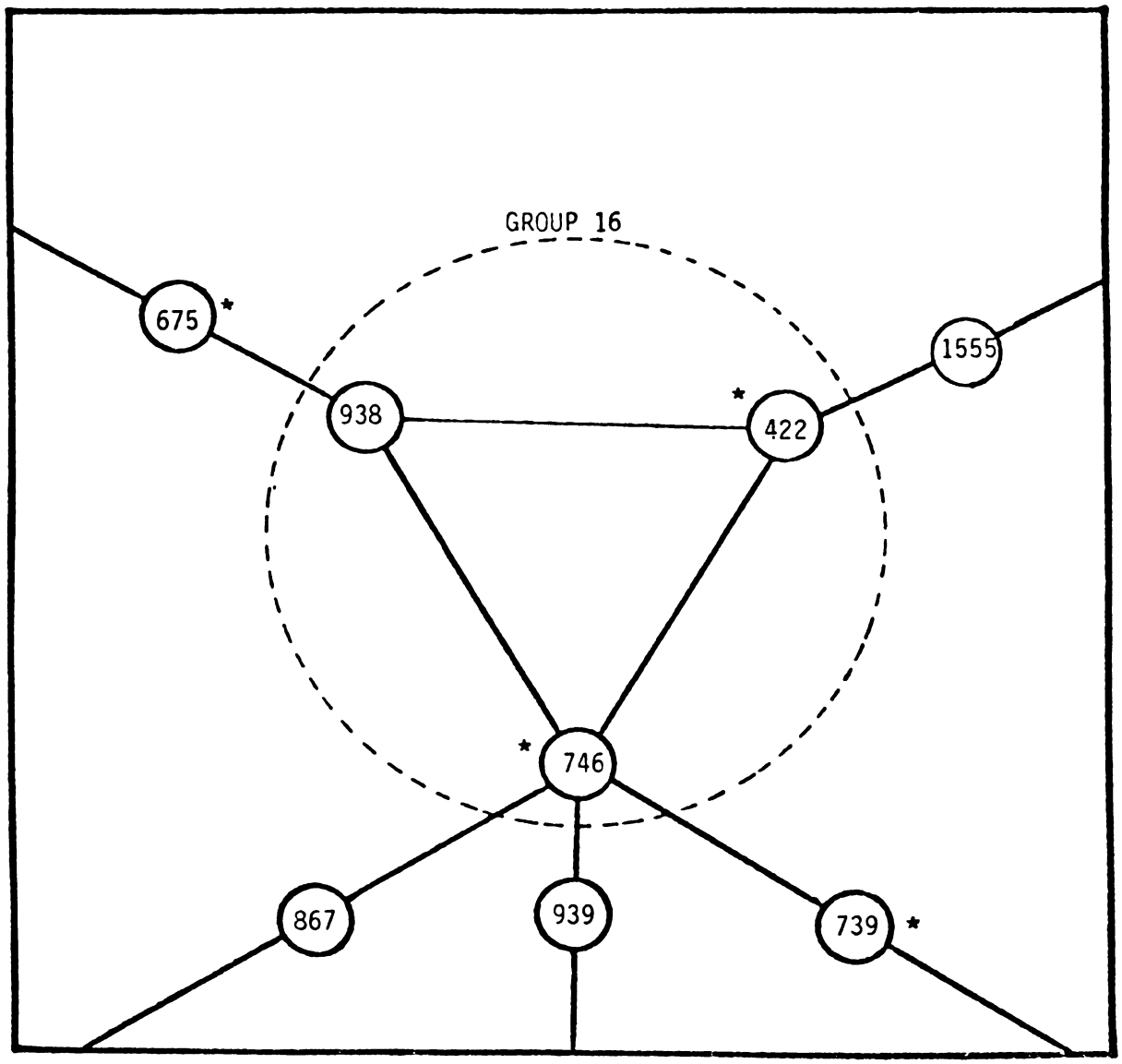
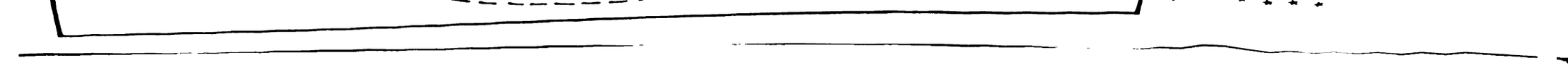


Figure 25. Group number 16, integrated by rice and bean researchers. Organizational affiliations of group members are:

*422 = ICA, Colombia
*746 = FEDEARROZ, Colombia
938 = FEDEARROZ, Colombia
* = Former CIAT trainee



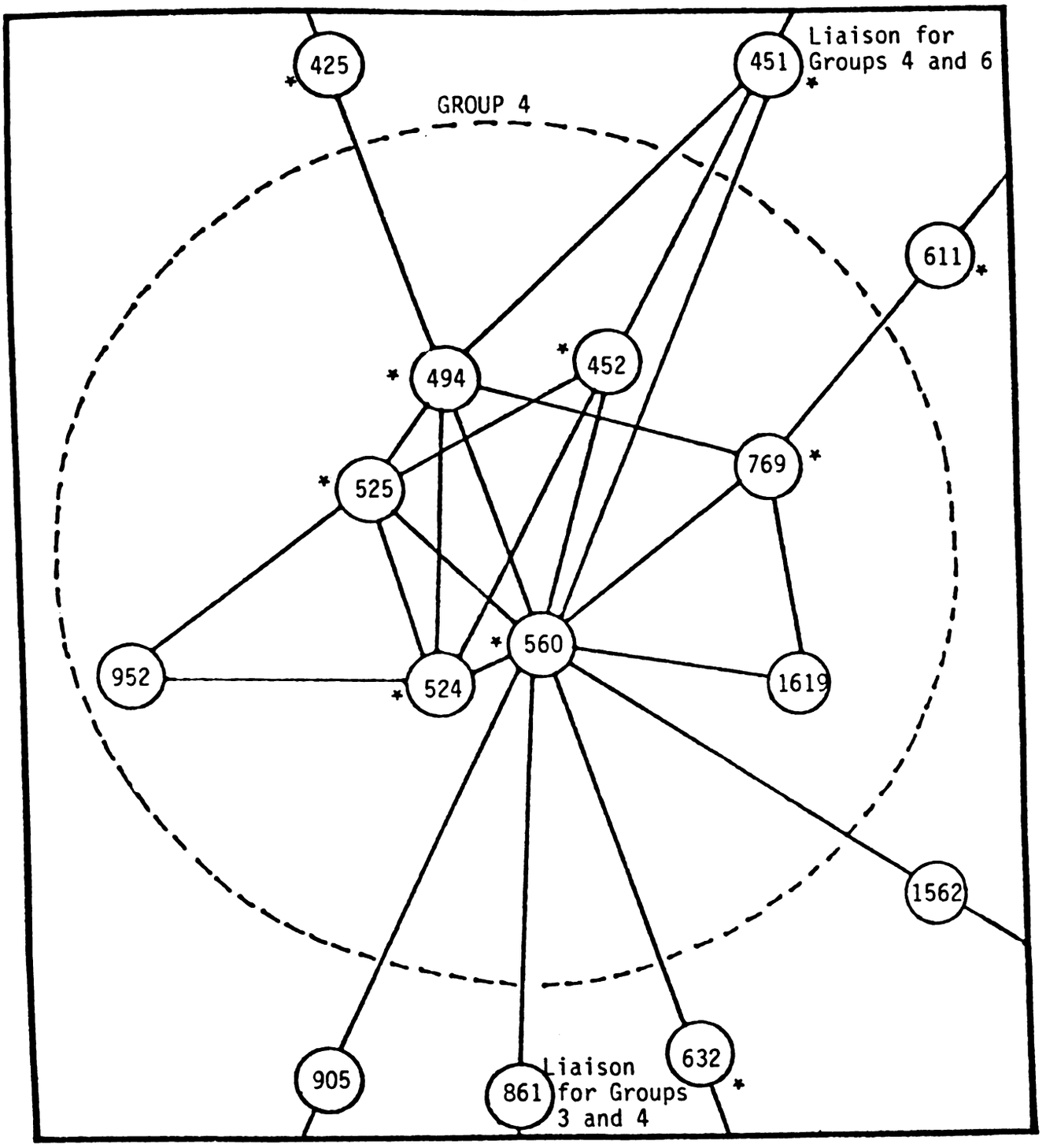


Figure 26. Group number 4, integrated by rice and bean researchers. Organizational affiliations of group members are:

*452 = Min. A&G, Costa Rica
*494 = Min. A&G, Costa Rica
*524 = Cons. N. P., Costa Rica
*525 = Cons. N. P., Costa Rica
*560 = Cons. Nal. Prod., Costa Rica
*769 = Cons. Nal. Prod., Costa Rica
952 = Of. Nal. Semillas, Costa Rica
1619 = Con. Nal. Produccion, Costa Rica

* = Former CIAT trainee

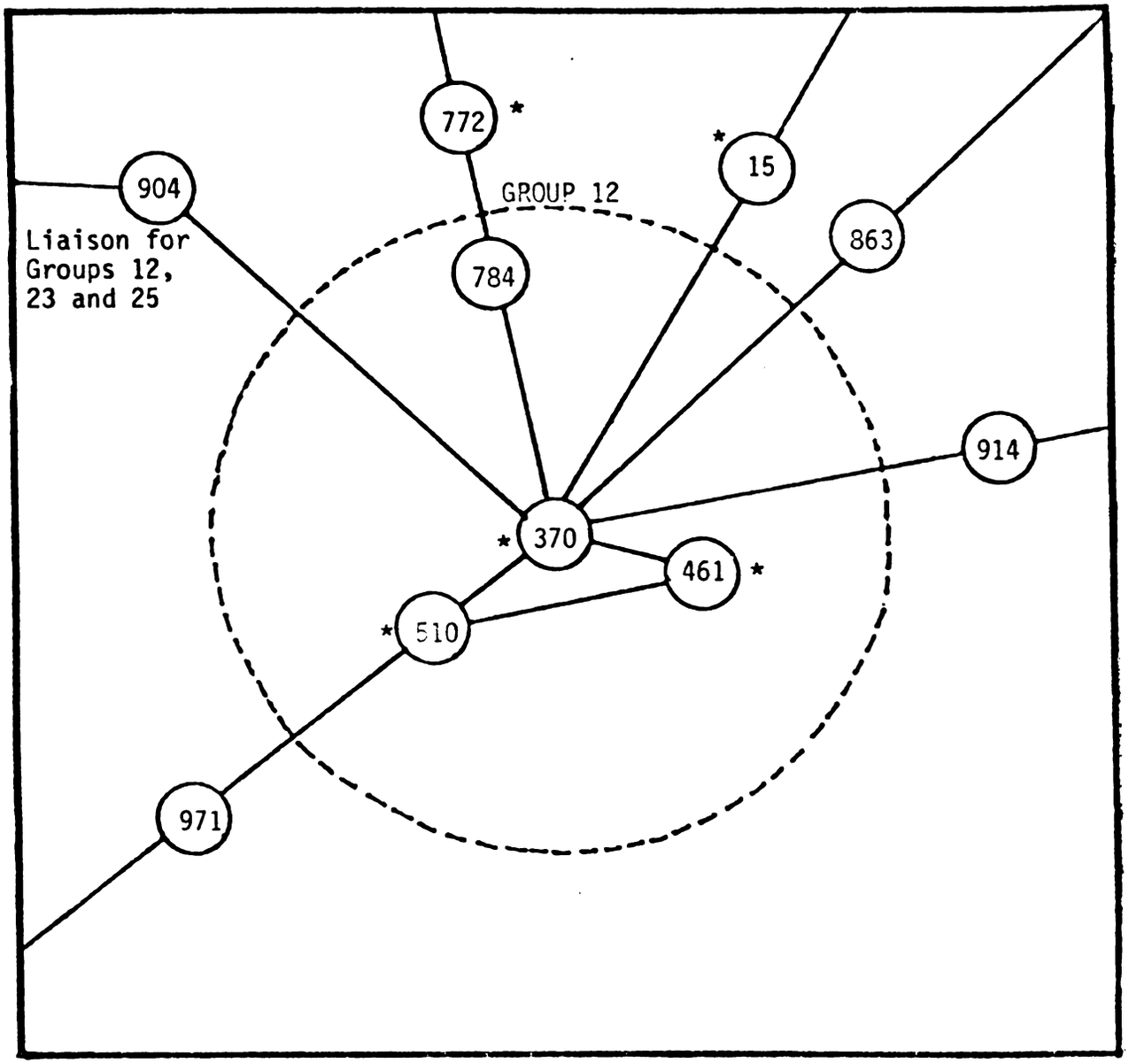


Figure 27. Group number 12, integrated by bean researchers. Organizational affiliations of group members are:

*370 = INIAP, Ecuador
*461 = INIAP, Ecuador
*510 = INIAP, Ecuador
784 = INIAP, Ecuador

* = Former CIAT trainee

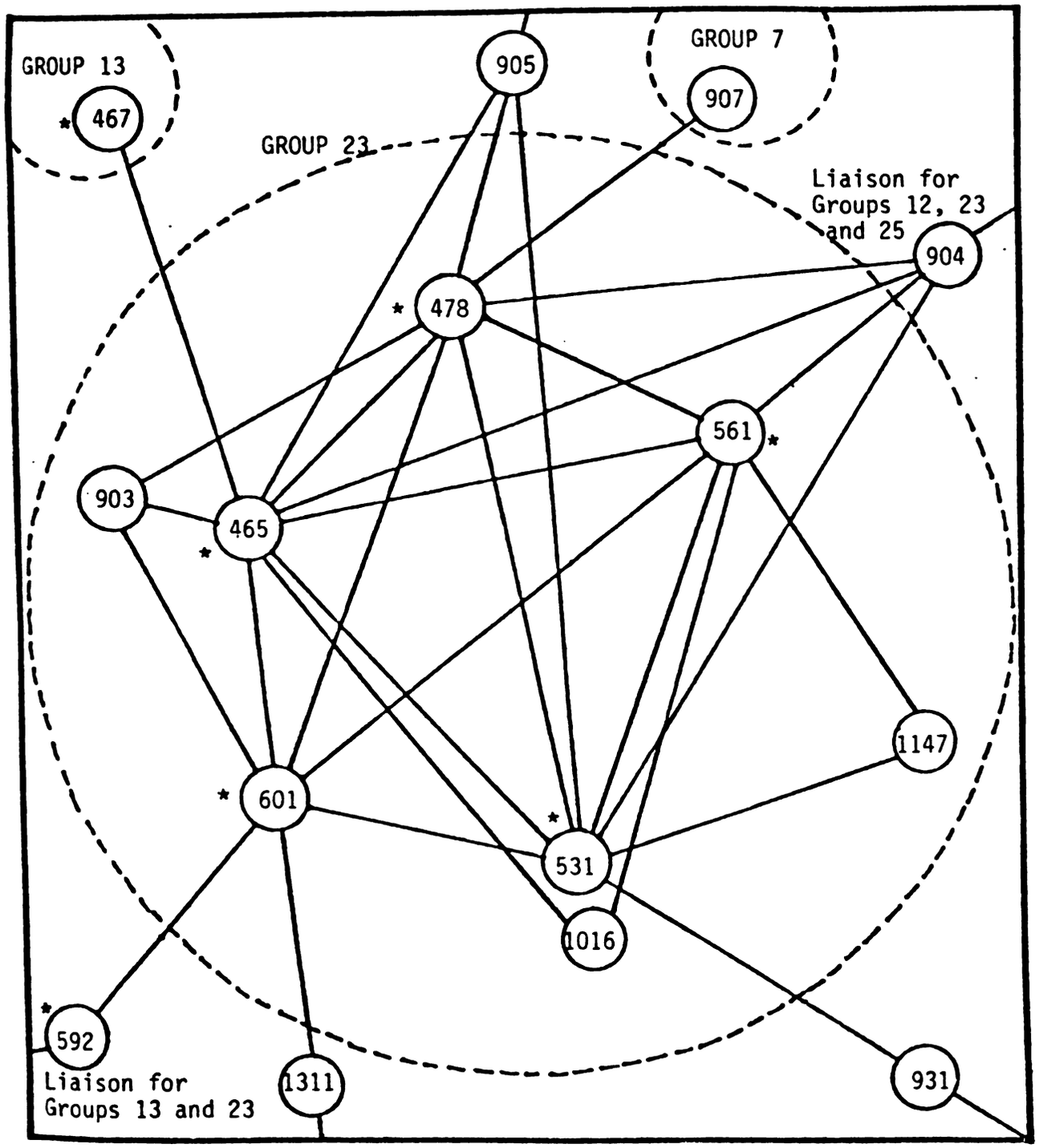


Figure 28. Group number 23, integrated by bean researchers. Organizational affiliations of group members are:

*465 = INIAP, Ecuador
*478 = INIAP, Ecuador
*531 = INIAP, Ecuador
*561 = INIAP, Ecuador
*601 = INIAP, Ecuador
903 = INIAP, Ecuador
1016 = CESA, Ecuador
1147 = CESA, Ecuador

* = Former CIAT trainee

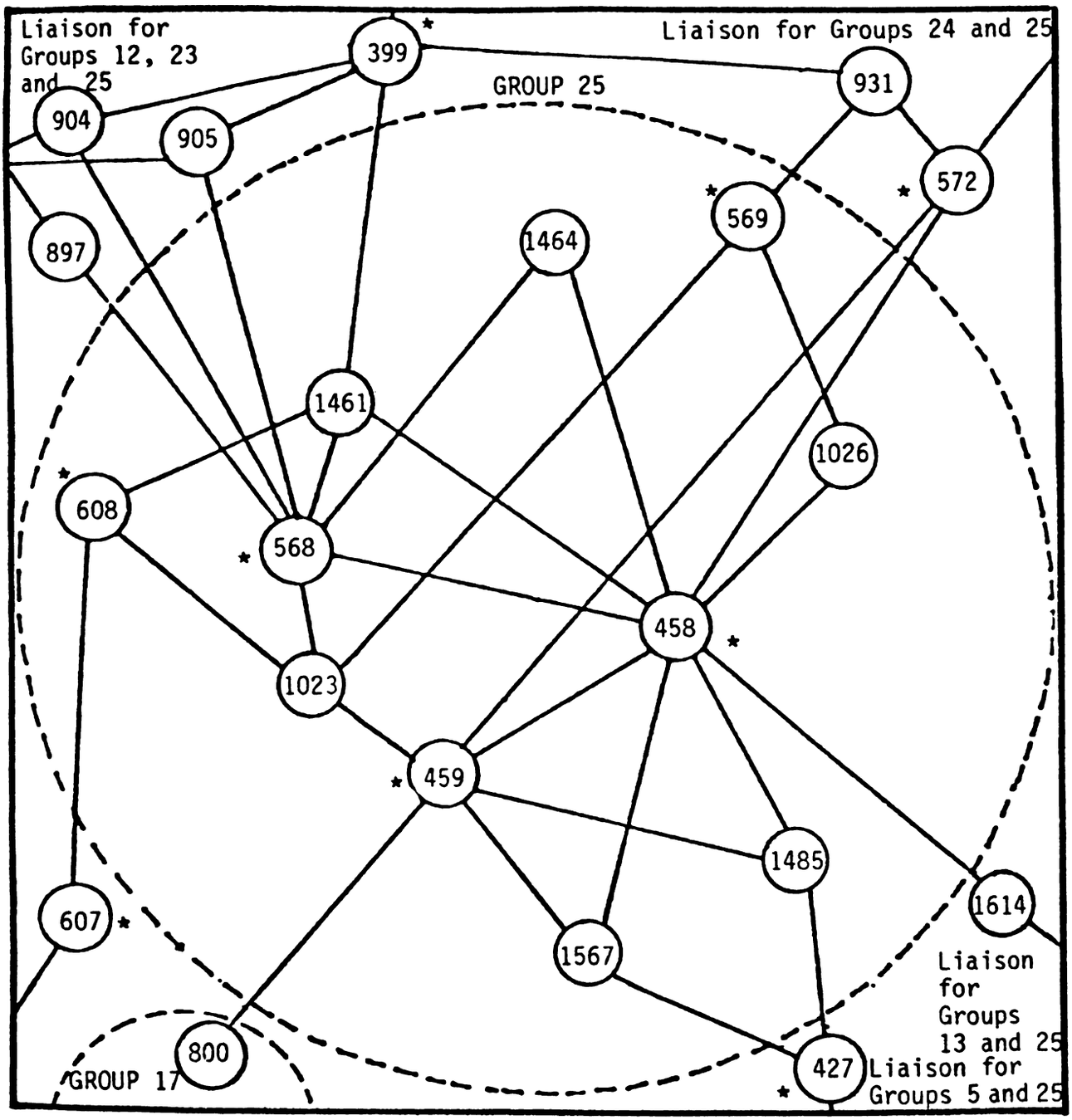


Figure 29. Group number 25, integrated by bean researchers. Organizational affiliations of group members are:

*458 = INIA, Mexico
*459 = INIA, Mexico
*568 = INIA, Mexico
*569 = INIA, Mexico
*608 = INIA, Mexico
1023 = INIA, Mexico
1226 = INIA, Mexico
1461 = INIA, Mexico
1464 = INIA, Mexico
1485 = Col. Post. Chapingo, Mexico
1567 = INIA, Mexico

* = Former CIAT trainee

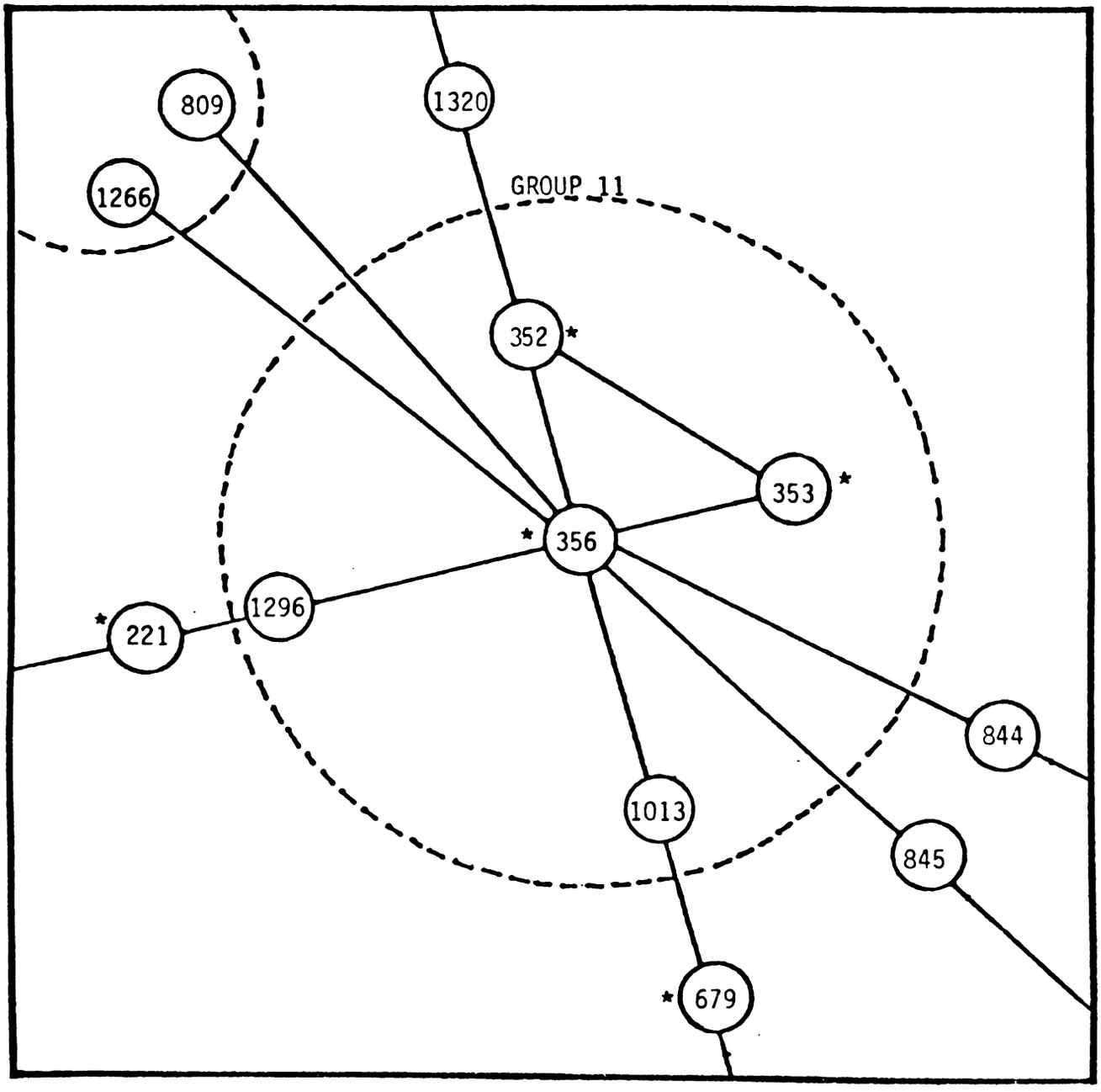


Figure 30. Group number 11, integrated by tropical pastures researchers. Organizational affiliations of group members are:

*352 = U. de Oriente, Venezuela
*353 = FONAIAP, Venezuela
*356 = FONAIAP, Venezuela
1013 = FONAIAP, Venezuela
1296 = FONAIAP, Venezuela

* = Former CIAT trainee

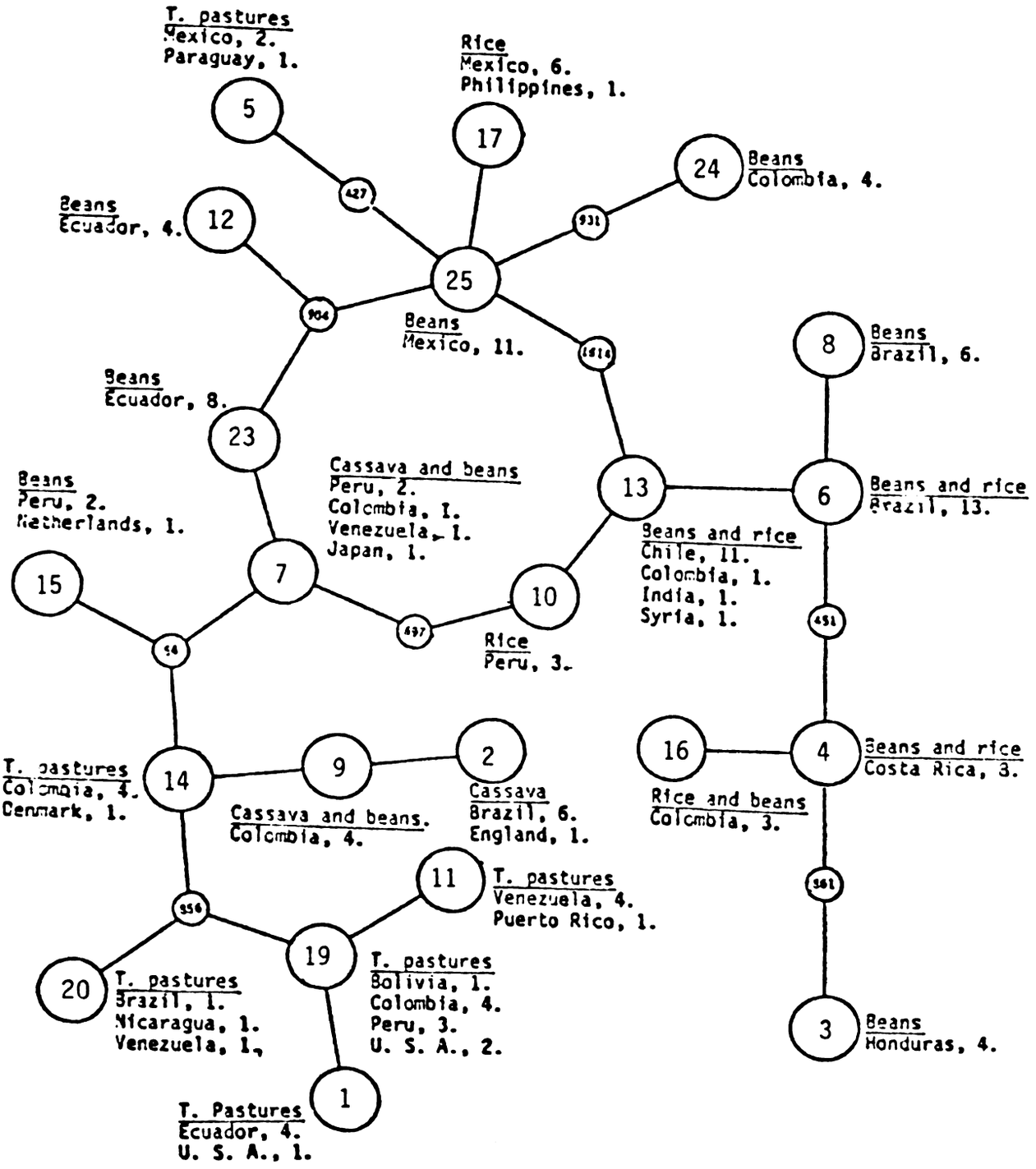


Figure 31. Research network mapped with base in a network analysis of data provided by 207 former CIAT trainees. To simplify the map, "others" and non-participants are not diagrammed. Numbers within circles are labels to identify groups. Small circles represent liaisons. Figures in front of the names of countries indicate number of group members working in those countries.

Table 31. Former CIAT trainees who are members of research groups, distributed by age, gender, marital status, and education.

Characteristic	Number	Percentage
Age (years)		
Less than 30	21	30.4
30 - 34	33	47.8
35 - 39	11	15.9
40 - 44	3	4.4
More than 44	1	1.5
	69	100.0
Gender		
Female	1	1.5
Male	68	98.5
	69	100.0
Marital status		
Single	25	36.2
Married	44	63.8
	69	100.0
Education		
Less than B.S.	1	1.5
B.S. or equivalent	59	85.5
M.S. or equivalent	7	10.1
PhD	2	2.9
	69	100.0

E. Relationships with three selected factors.

1. Participation and training content. The selection of content as a factor of interest for this study assumes that a researcher's performance is affected by the cognitive nature of his/her research tasks. Another related assumption is that the nature of these tasks is tied to the differential historical development of scientific fields and modes of production. For instance, when cassava researchers perform differently from rice researchers, this is associated not only with the contrasting character structures of the persons who carry out research tasks in these specialized fields, and with particular conditions of the organizational environments in which they work; differential performance is associated also with the disimilar characteristics and stage of development of research traditions and modes of production of rice and cassava. This is not to say that doing research on cassava is more or less difficult than doing research on rice, but simply that the two differ. (An overview of the research traditions and modes of production of rice, beans, cassava, and tropical pastures is presented on pp. 66-73).

A chi-square test suggests that proportions of network participants and non-participants distributed by training content are different among the sample studied (Table 32 and Figure 32). There is a higher rate of participation for beans and rice former trainees who have engaged in research (approximate ratios between participants and non-participants are 4:1 in beans and 3:1 in rice), and lower participation for cassava and tropical pastures trainees (ratios are 2:1 in cassava and 1:1 in tropical pastures).

Table 32. Participation in networks of researchers, distributed by training content.

Variable	Participants		Non-participants		Total	
	n'	%	n'	%	n	%
Training content	141	68.1	66	31.9	207	100.0
Rice	24	75.0	8	25.0	32	100.0
Beans	71	78.9	19	21.1	90	100.0
Pastures	19	45.2	23	54.8	42	100.0
Cassava	27	62.8	16	37.2	43	100.0

Chi-square = 32.17. Statistically significant at alpha level 0.05.

To further pursue the exploration of this relationship, linkages are dissaggregated by locus of incidence. Given that the number of respondents differs within each category of independent variables, a standard index is constructed by dividing the number of links for each category by the number of respondents in each category (Table 33). Before generalizing about the class of data, a word of caution is presented here. Methodological considerations preclude applying statistical tests to the data arranged in this way. Instead, the writer merely looks for patterns in the actual values of the indexes; differences in these indexes may well have occurred by chance.

Looking at the total number of links per respondent for each field, the pattern observed in the preceding analysis emerges again, with those trainees in rice and beans better connected than their colleagues in tropical pastures and cassava. However, within specific loci of incidence new patterns emerge. Interpersonal contacts at the worldwide level show higher indexes in the fields of rice and tropical

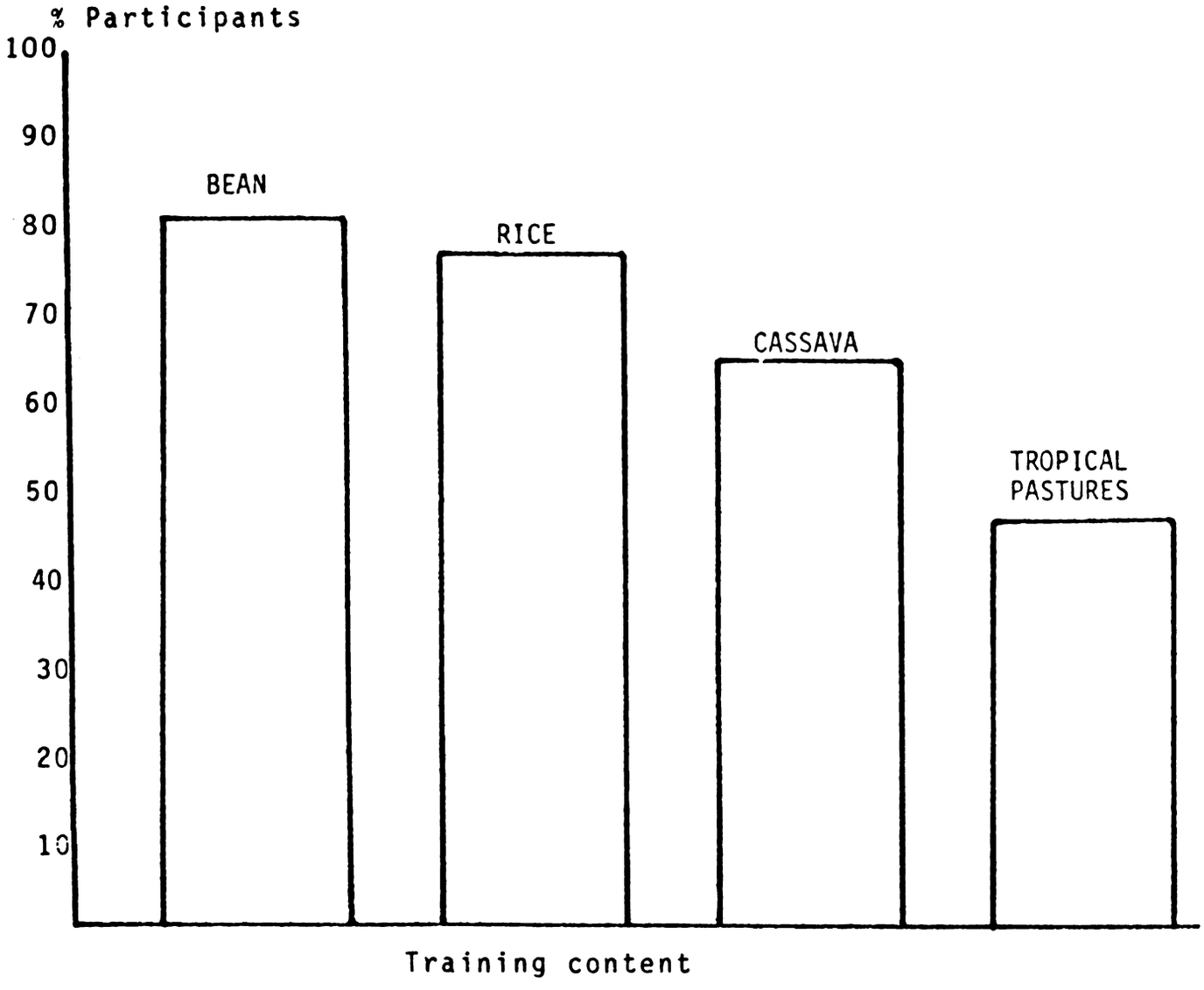


Figure 32. Percentages of participants in research networks, represented in relation to training content.

Table 33. Linkages of participants at four loci of incidence, distributed by training content.

Locus of incidence	Training content				
	Rice	Bean	T. Pastures	Cassava	Total
Organization					
Number of links	98	283	58	90	529
Index	4.08	3.99	3.05	3.33	3.75
Country					
Number of links	86	213	47	83	429
Index	3.58	3.00	2.47	3.07	3.04
Latin America					
Number of links	47	132	40	42	261
Index	1.96	1.86	2.11	1.56	1.85
World					
Number of links	23	34	16	16	89
Index	0.96	0.48	0.84	0.59	0.63
Total					
Number of links	254	662	161	231	1308
Index	10.58	9.32	8.47	8.56	9.28
Number of respondents	24	71	19	27	141

pastures than in beans and cassava. It is also noticeable that researchers in the field of tropical pastures show the lowest index of connections compared with researchers in the other three fields at the level of country and organization, and slightly higher for the Latin American region. Researchers in the fields of beans and cassava exhibit the lowest indexes of linkage at the worldwide level.

A last examination of the relationship between participation in research networks and training content arises from disaggregating participation in terms of network roles, and then focusing on the proportions of group members within each content. This focus on group members is based on the high significance that "invisible colleges" have within research networks. (Liaisons are also very important, but their reduced number does not allow one to make comparisons.) The proportion of group members is higher in the fields of bean (44%) and tropical pastures (36%), intermediate for rice (28%), and lowest for cassava (12%). The high proportion of group members in tropical pastures sharply contrasts with the circumstance that this same field exhibitis the highest proportion of non-participants (55%) in this sample (Table 34).

2. Participation and length of training. Unexpectedly, length of training is inversely related to participation in networks of researchers (Table 35). This result is contrary to the general assumption made in the design of training programs at CIAT (see p. 98), and also contrary to the relationship observed formerly between length of training and number of years that practitioners stay doing research after training (see pp. 128-131).

Table 34. Network roles, distributed by training content.

Role	Rice n'	Rice %	Beans n'	Beans %	Pastures n'	Pastures %	Cassava n'	Cassava %	TOTAL n	TOTAL %
Participants	24	75.0	71	78.9	19	45.2	27	62.8	141	68.1
Group members	9	28.1	40	44.4	15	35.7	5	11.6	69	33.3
Liaisons	1	3.1	2	2.2	0	0.0	1	2.3	4	1.9
Others	14	43.8	29	32.3	4	9.5	21	38.9	68	32.9
Non-participants	8	25.0	19	21.1	23	54.8	16	37.2	66	31.9
Tree nodes	7	21.9	14	15.6	19	45.2	9	20.9	49	23.7
Dyads	0	0.0	3	3.3	1	2.4	0	0.0	4	1.9
Isolates type 2	0	0.0	2	2.2	0	0.0	1	2.3	3	1.4
Isolates type 1	1	3.1	0	0.0	3	7.2	6	14.0	10	4.9
TOTAL	32	100.0	90	100.0	42	100.0	43	100.0	207	100.0

Table 35. Participation in networks of researchers, distributed by length of training.

Variable	Participants n'	Participants %	Non-participants n'	Non-participants %	Total n	Total %
Length of training	141	68.1	66	31.9	207	100.0
Two months or less	76	73.1	28	26.9	104	100.0
More than two months up to six months	47	71.2	19	28.8	66	100.0
More than six months	18	48.7	19	51.3	37	100.0

Chi-square = 14.82. Statistically significant at alpha level 0.05.

This puzzling relationship is examined again in terms of linkage locus of incidence. Practitioners who had an intermediate period of training exhibit higher linkage indexes than people in the other two categories, at three loci of incidence with the exception of the level of country, in which the lowest index of linkage is associated with intermediate training (Table 36).

Altogether, trainees in all three categories of length show high indexes of connections within their countries as a whole. In the region and on a global scale, persons who had intermediate and longer training have higher proportions of linkages than those who had only two months or less of training (Table 36).

In Table 37 the role of the group member is disaggregated by length of training. A clearer pattern emerges suggesting a curvi-linear relationship, in which intermediate training is correlated with the highest proportion of group members.

Table 36. Linkages of participants at four loci of incidence, distributed by length of training.

Locus of incidence	Length of training			Total
	$m \leq 2$	$2 < m \leq 6$	$m > 6$	
Organization				
Number of links	283	179	67	529
Index	3.72	3.81	3.72	3.75
Country				
Number of links	272	113	44	429
Index	3.58	2.40	2.44	3.04
Latin America				
Number of links	117	109	35	261
Index	1.54	2.32	1.94	1.85
World				
Number of links	25	50	14	89
Index	0.33	1.06	0.78	0.63
Total				
Number of links	697	451	160	1308
Index	9.17	9.60	8.89	9.28
Number of respondents	76	47	18	141

Altogether, trainees in all three categories of length show high indexes of connections within their organizations. Short term trainees have a higher index within their countries as a whole. In the region and on a global scale, persons who had intermediate and longer training have higher proportions of linkages than those who had only two months or less of training (Table 36).

Table 37. Group members, distributed by length of training.

Length of training	Group members	Percentage of sample	Sample size
Two months or less	32	31%	104
More than two months, up to six months	30	45%	66
More than six months	7	19%	37

Finally, this relationship is examined within training contents, selecting again as a focus the number of group members, given the relevance of this role within a research network. The curvilinear pattern suggested in the preceding paragraph consistently emerges within all four training contents (Table 38 and Figure 33).

Table 38. Group members, distributed by content and length of training.

Training content	Length of training: Short		Intermediate		Longer		Total	
	Number	%	Number	%	Number	%	Number	%
Rice	4	29	5	33	0	0	9	28
Bean	23	43	13	50	4	36	40	44
T. pastures	2	40	11	52	2	13	15	36
Cassava	3	9	1	25	1	14	5	12
TOTAL	32	31	30	45	7	19	69	33

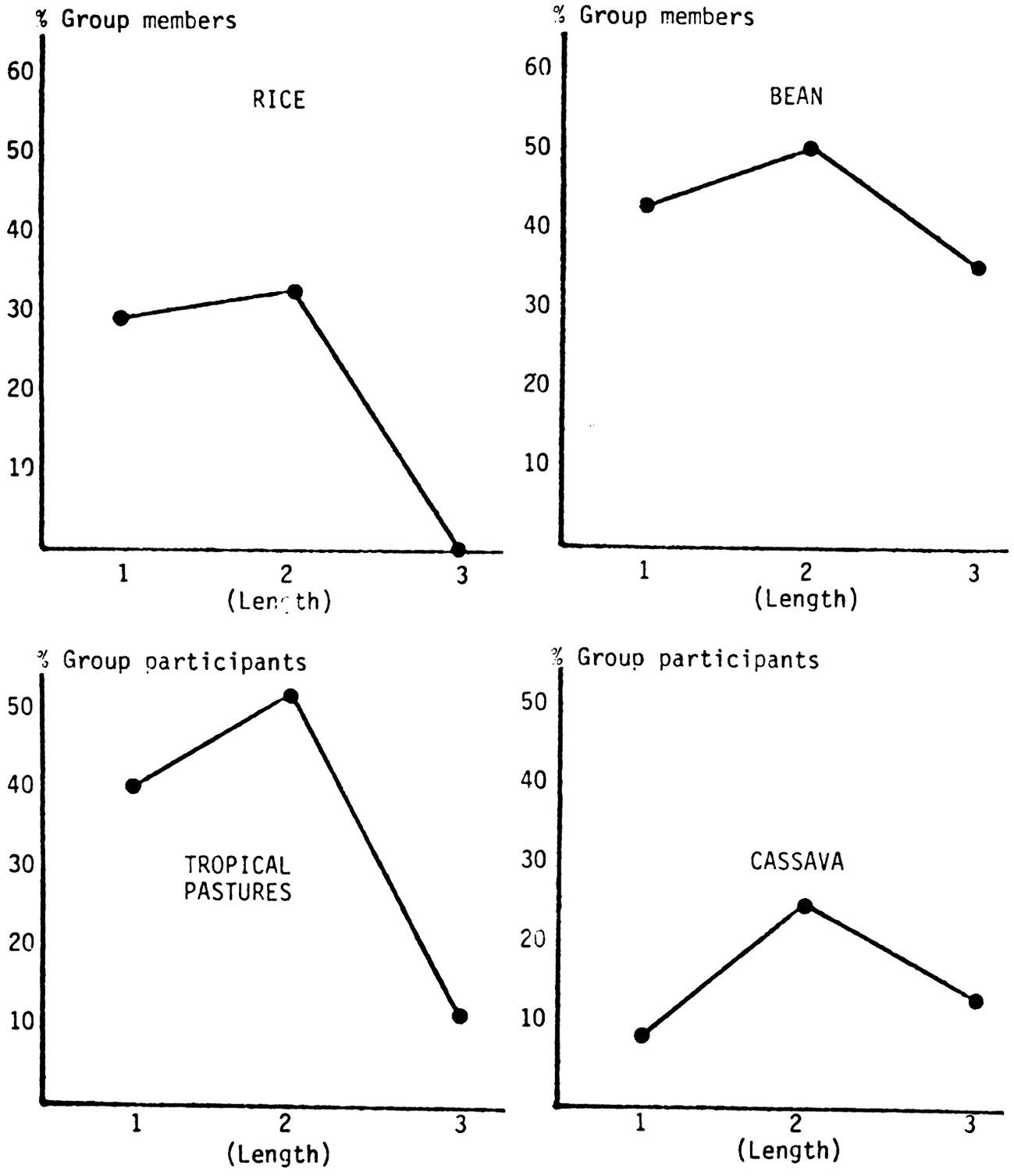


Figure 33. Percentages of group members represented in relation to length of training.

3. Participation and facilities to do research. Data grouped in terms of more and less facilities to do research in the fields of training at home organizations do not show statistically significant differences (Table 39). This result conforms with what was observed before in the relationship between research facilities and number of years that practitioners stay doing research after training (p. 132-4). This is an unexpected finding which may be associated with the gross categories used for the variable research facilities. In spite of the lack of statistically significant differences, a slight difference seems to exist in the data suggesting a possible positive correlation between participation in networks of researchers and facilities to conduct research at home organizations.

Table 39. Participation in networks of researchers, distributed by facilities to do research at home organizations.

Variable	Participants		Non-participants		Total	
	n'	%	n'	%	n	%
Facilities to do research	141	68.1	66	31.9	207	100.0
More facilities	104	68.9	47	31.1	151	100.0
Less facilities	37	66.1	19	33.9	56	100.0

Chi-square = 0.23. Not statistically significant at alpha level 0.05.

CHAPTER VI

SUMMARY, IMPLICATIONS, AND INTERPRETATIONS

This study of research training at an international agricultural research center has focused on two aspects of the former trainees' performance: 1) to what extent is the Latin American region building inventories of human resources for agricultural research based on CIAT's training?, and 2) to what extent are former CIAT trainees participating in third cultural networks of science and technology?

The relationships of three independent variables to both inventories and network participation were examined. The three factors are: training content, length of training, and facilities to do research in the fields of training at home organizations.

A. Distinctive character of the study's population.

The researchers and their work related experiences and structures--the center of attention of this thesis--are not members of those communities which have received primary attention in studies of the sociology of science, nor in the accounts of institution building of agricultural science in the developed and developing countries. Such studies have focused on Nobel laureates, on professional doing "pure" or "basic" research, on the careers of famous people in "glamorous" fields like high energy physics, on the "fathers" of the green revolution, and on members of academia in MDC's and LDC's who are influential in the central

bureaucracies of their nations and international agencies, as well as integrated in the world-encompassing networks of research and development enterprises.

By contrast, this study's population is composed of young scholars who usually were in their first job assignments when they entered CIAT's training; for many of them their stay at CIAT in Colombia was their first trip out of their home land, their first opportunity to interact with members of other cultures, and their first chances to become personally acquainted with people whom they regard as highly competent professionals. The vast majority of them still do not hold formal degrees beyond the B. S. level, and occupy middle level professional positions within large, complex agricultural research organizations. Their job assignments are usually defined as relatively specialized full time research. In most cases they are not part of an agricultural technology delivery system.

In their work they often are not the conceptualizers of research, but rather they are mediators between those who produce new S&T for agriculture and the users of such knowledge (farmers, extension staff, people in agrobusinesses). As mediators they usually do not live in the capital cities but in the countryside close to the production units (farms) for which they test and make adaptations to already available technology. Most of them have not published in the international journals of the world centers of science, are not listed in the science citation index, and few are influential in the policy-making of the bureaucracies of their countries. They are seldom thought about in writings of macrolevel plans for generating an endogenous science for appropriate technology. Notwithstanding, these are the researchers who are trying to make technological options relevant and applicable for increasing agricultural

production and productivity in their immediate localities and countries. Given the location-specific nature of farm problems in conjunction with part of the agricultural technology, without the continuing work contributions of these researchers a large segment of new S&T may remain useless for development. As professionals and human beings they have an identity of their own, they have dignity, and they deserve respect. In sum, they are more than simple aggregates of low level scientific manpower who are marginal appendices of the upper level hierarchies of their research organizations or of the international research communities.

B. Summary of findings.

1. Findings on inventories of researchers. The data for this study of inventories come from a census of 182 agricultural organizations in 26 Latin American and Caribbean countries which sponsored persons for research training at CIAT during the period 1969-79.

a. The forming of inventories of human resources for staffing the intermediate level of agricultural research organizations in Latin America through CIAT's training has been an effective process. It exhibits some inefficiencies in regard to the ability to retain trained persons in the sponsoring organizations and in the activity of research. However, beneath the surface of obvious loss are more complex and unexamined consequences of the internal brain drain. Individuals who have left their sponsoring organizations may nevertheless perform significant roles in other positions tied to agricultural research and development. Effectiveness of the process is supported by annual net balances and final inventories which during the entire period are positive and increasing. Inefficiencies are due to a growing process of migration of trained persons towards sites and tasks other than those of their sponsoring organizations, fields of

training, and the activity of research. This migration has directly constrained in particular the forming of a "critical mass" of qualified professional to establish collaborative research linkages between CIAT and counterpart organizations in the region.

Four out of every five are still agricultural researchers, and over half (57%) of them work in those training commodities (rice, bean, tropical pastures, and cassava). Another fourth (24%) shifted to other types of research, either within their sponsoring organizations or elsewhere. Slightly one fifth (19%) have left research activities.

b. Migration, disaggregated in two components (non-return and drop-out) shows different magnitudes and tendencies. The non-return to sponsoring organizations and fields of training is higher than drop-out. But the trend in the proportion of non-return during the last four years is showing a decreasing tendency. On the contrary, drop-out represents a smaller proportion of migration than what is accounted for by non-return, but during the whole period 1969-79 drop-out presents an increasing tendency.

The impact of the components of migration on inventories varies with the perspectives from which these processes are examined. Thus, from the view of "sponsoring organizations" and "research in general" the major proportion of migrants consists of professionals who return to their organizations and their research role, but later on drop-out. This phenomenon has been one of relatively low magnitude during the first half of the decade analyzed, but rapidly increased during the second half of this period. From the perspective of the "fields of training" and "CIAT commodities" most of the migration is due to non-return of professionals to this activites immediately after training; non-return shows a high

magnitude during the first half of the training period, but has rapidly decreased during the latter years.

c. Put in a time frame, efficiency in retaining trained persons and research experience was low during the first years of CIAT's training, but since 1975 has shown a consistent tendency to increase, from the four perspectives analyzed.

d. The length of stay in sponsoring organizations, specialized fields of training, and in research activities manifest a decreasing trend throughout the first five to six years after training, but beyond this interval there is a slight increasing tendency for staying in the same organizations and fields among those practitioners who still have not left research.

e. The total span of years that members of the sample continue in their sponsoring organizations, fields of training, and activity of research, is positively related to the length of their CIAT training experiences. It is not related to the facilities available in their work organizations in their specialized fields of training.

2. Findings on research networks. A substantive proportion of former CIAT trainees participate in research interchanges with relevant colleagues and form networks which have a third cultural character. There is solid evidence that identifiable social structures have emerged out of the research interactions in which these agricultural researchers participate. However, not all former CIAT trainees are well connected to these networks: among the proportion who are non-participants there are different degrees of isolation.

a. Participants. About two thirds of the persons in the sample network analyzed participate in communities of researchers.

b. Third cultural networks. Slightly over one out of every four (27%) of the participants linkages extend beyond their home country, with most of these ties being with their counterpart researchers working in Latin America (20%). Among the participants in transnational networks, seven percent have personal professional ties beyond the region with colleagues working in some part of the rest of the world. Two thirds of all their linkages are of an intensive nature, and about one third of the intensive relationships occur at the region or worldwide level.

c. Social structures. The networks generated thorugh the recurrent interaction of participants with professional colleagues are highly structured. Twenty-two research groups ("invisible colleges") were identified; most of them are specialized: seven in bean research, six in tropical pastures, two in rice, and one in cassava. The size of the groups varies between three and fourteen persons. Most groupings are interorganizational and half of them are transnational. Some of the transnational linkages include researchers of international centers, but it is noticeable that these research groups do not include professionals working for two of the centers which operate in the region, CIMMYT and CIP. These twenty two different research groups are interconnected with each other through the links of some of their individual members who play the role of bridges. Nine persons perform as liaisons; four of these liaisons are former CIAT trainees. Similar to the total population of former CIAT trainees, participants are young males with an education at the B. S. level.

d. Relationships with independent variables. Participation in research networks varies with training content and length of training, but not with facilities to do research at home organizations. The

highest proportions of participants are in the fields of rice and bean, and the lowest in tropical pastures and cassava. However, when participants are disaggregated by network roles, bean and tropical pastures are the fields with highest proportion of group members, rice is intermediate and cassava is the lowest. Linkages are more transnational in the fields of rice and tropical pastures, and more localized within organizations and countries for bean and cassava researchers. These relationships reflect the structural character of the content factor. In fact, there is a more developed infrastructure in Latin America for enterprises related to rice and bean production and marketing, and a less developed infrastructure for cassava. Tropical pastures are an intermediate input for beef production, which also has a more developed infrastructure than cassava. Both cassava and tropical pastures are newer fields of research than rice and beans. Rice and tropical pastures are more worldwide concerns which is reflected in the apparently more "cosmopolite" linkages of researchers in these fields. In contrast, bean and cassava research are more domestic concerns at present, and this appears to be reflected in a more "localite" orientation of the professional linkages in these fields.

There is a curvilinear relationship between length of training and participation of research networks with those persons who have an intermediate training presenting the highest proportion of participation. This is a puzzling relationship whose understanding requires further investigation.

e. Non-participants. One third of this study's sample do not participate in networks of researchers. The highest number and proportion of non-participants are in the field of tropical pastures.

C. Implications.

The following section attempts to suggest practical implications of the empirical results for CIAT, for international sponsors of agricultural research, for country-based science policy makers, and for scholars in agricultural development and education.

1. Implications for CIAT. A selective aspect of the two research questions examined in this study can be pursued further in relationship to these findings. On one side, a heavy migration outside the fields of training was clearly evident in the study's data; on the other an intensive process of networking emerged. The facts about migration suggest a strategy of continuously training twice the number of persons estimated as the "critical mass" required. Findings on networks indicate that numerous research groups have emerged across the region in relationship to CIAT's training and communication strategies. These "invisible colleges" are social structures which have been associated in the sociology of science with the most productive individuals in specialized fields of research. The existence of these social structures among Latin American agricultural researchers opens a new option to CIAT for policy-making and resource allocation with regard to training. An appropriate route for strengthening agricultural research in Latin America seems to be to invest more in networking. CIAT already has in its own structure excellent facilities for stimulating the emergence and functions of these social structures: documentation centers, publications, training and conferences facilities, as well as an active component of international cooperation for research interchanges of materials and expertise. A series of newsletters have been published and distributed in recent years by each commodity program. Although some directories of researchers

have been prepared and distributed, this might be an area which invites more recurrent attention in the future. All these components might be explicitly and formally integrated in a systematic strategy for encouraging and sustaining research network development.

With regard to the issue of the length of training, the duration of training experiences relates to the content of learning objectives formulated for particular training programs. Perhaps, allocation of resources to longer durations should be considered only after conducting further analysis of instructional design.

Finally, major potential sources of improvement in the length that practitioners stay in the activity of research must be discerned and managed from a better understanding of the complex of reasons that professionals have for leaving their organizations and the activity of research.

2. Implications for international sponsors of agricultural research. What emerged out of the study of interpersonal professional linkages among former CIAT trainees were findings about a new and distinctive type of network which is role-related and professionally meaningful for these researchers at work. These networks are not simply sets of friends who occasionally meet to politely reaffirm their interpersonal ties with one another. These networks are structured communities of working scholars. Research networks regularly provide to their members important resources and social-psychological support in their work roles.

This finding on the existence of active social structures among agricultural researchers in Latin America allows one to make the following suggestion to research and development sponsors:

the encouraging and supporting of networks of intermediate level agricultural researchers across the region may be as important for a genuine institutionalization of S&T for agricultural and social development aims as is the more specialized and planned building of formal organizations for the same purposes.

The findings of the study of these social structures imply that opportunities now exist for selectively allocating resources for a better understanding by administrative leadership of the process of research network development (RND), and a comprehension of how these networking processes function to complement other organizational procedures for creating realistic supportive systems for the generating and sustaining of these communities of researchers. These efforts would constitute complementary strategies for institution building of science development, and might result in mutually supportive coexistence of both the formal organizations of research and the communities of researchers.

3. Implications for country-based science policy makers. The outcome of this study on inventories of researchers show an increasing migration of trained persons out of the sponsoring organizations and out of the activity of research. This migration supports the assertion made in other studies about an apparent declining trend of agricultural research as a powerful social value in Latin American societies. (This loss of value, of course, refers to the region as a whole. It is well known that individually several countries are presently engaged in ambitious programs of agricultural research, e. g. Brazil, Mexico, and Venezuela).

On the other hand, the findings of this study on research networks allow one to have an alternative view of the process of science development. A perspective on research networks opens fresh ways of looking more closely at some of the pervasive macro-level concerns of many science policy makers throughout the region on the phenomenon of "brain drain". From a network perspective, the horizontal mobility of researchers from organization to organization, or from country to country within the region, does not necessarily need to be assumed to constitute a total loss of skilled persons. Researchers in general are mobile persons; their continued interchanges with colleagues in other societies and cultures enables them to elicit reactions to their own thinking and cope reciprocally to keep abreast of the new achievements in other parts of the world. As long as researchers continue actively interchanging their findings, paradigms, and methodological breakthroughs with other members of their research networks, the circumstance of the specific location where they are working may be of secondary importance, and calls for a more sophisticated search for understanding the cross-cultural transfer of technology.

4. Implications for scholars in agricultural development. A central implication of this study for scholars in agricultural development is the need to reconceptualize the agricultural research system. Current conceptualizations tend to assume that the only components of this system are the formal organizations of research and education. These conceptualizations implicitly ignore the existence and functions of the "invisible" communities of researchers, to say nothing of the farmer-researcher networks.

5. Implications for the field of Educational Systems Development. A main implication of this exploratory study for ESD is the potential for use of social-psychological variables in the design of educational systems. These variables may be particularly relevant in the area of faculty development, but instructional development and organizational development strategies may also be improved with the inclusion of those social-psychological factors. Learning has been largely conceived and applied in system design as an individual process, restricted to the psychological sphere. The inclusion of social factors involved in learning may constitute a source of improvement in the formulation of systematic strategies for educational goals and achievement. Two additional implications of this study for ESD refer to the use of network analysis as a tool for practitioners in this field and the potential of ethnography as an alternative research method.

6. Two issues on education in general. From this study of networks among former participants in a non-degree training program at least two issues arise for higher education: a) how to integrate non-degree training programs--which appear to be highly effective for selected educational goals--with formalized degree programs in higher education organizations of LDC's and MDC's; and b) how to integrate these processes of development of communities of intellectual workers in the formalized conceptions about the role of education in society. These two issues are suggested for future study by scholars interested in higher education.

D. Interpretation.

This interpretive section attempts to advance one step beyond the empirical data collected for this study, and hypothetically look for

additional meanings about the main findings of the study. These interpretations reflect three types of experiences of the author of this thesis: 1) in-depth interviews with selected members of the study population,* 2) the author's personal interchanges with Latin American agriculturists during several years of involvement with CIAT's training programs, and 3) the study of the literature on the sociology of science and on the emerging third cultures of scientific communities in developing countries. Readers of this section may keep in mind that all the following comments are speculative in nature.

1. Assessing the inventory formation process. How does one assess this inventory formation process? Are figures too high or too low? Are there some findings to be concerned with? It depends on who makes the assessment. Standard criteria based on previous research are not available, to the knowledge of the author.

First of all, the general picture of the inventory analysis, as well as field observations made during the data collection process, suggests that most former CIAT research trainees had had no trouble finding a job after training. This is remarkable in a region where unemployment exists among agricultural professionals. Perhaps the contrary has occurred: immediately after training, they have not only had the option of returning to their research duties in their sponsoring organizations, but have found opportunities to engage in activities other than research and with organizations other than those which

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* These interviews were conducted as part of the data collection for this thesis; however, they were not systematically reported in this thesis due to time and funds limitations.

sponsored their training. If this has been the case , it may indicate that CIAT's training is highly regarded, not only for preparing personnel for research, but for other professional work in agriculture, e. g., extension, teaching, commercialization of agro-chemicals, credit, technical assistance to and administration of commercial farms, among others. It is likely that from positions like those, the 19% of former CIAT research trainnes who left the practice of research may be contributing to food production and economic growth.

Second, from the perspective of preparing research workers for the region, the accomplishments seem very good. Four fifths of the people prepared during the 11-year period still participated in research activities in 1980, including those who were working on research areas different than their training fields. Specialized training is likely to be useful for working with a variety of species (commodities) and research approaches. It is probable that research techniques, the attitudes toward the conduct of research, the organizational frameworks of research, and other learnings acquired by professionals during their training at CIAT, as well as the contacts they made there with significant colleagues from other organizations and countries, have enabled CIAT trainees to do research in fields other than those of their specialized training. Therefore, these persons--24% of whom have engaged in research with other than CIAT commodities--may also be contributing to increased food production and economic growth in their countries. Moreover, they may be performing instrumental roles in the institutionalization of S&T as endogenous systems of Latin American societies.

Third, from the perspective of the sponsor organizations, the re-entering, stay, and retention of former CIAT trainees seems to offer a more encouraging picture than the general tendencies observed in the PROTAAL studies (pp. 39-44). Three-fourths of the persons trained between 1969 and 1979 were still in their sponsor organizations in 1980. This does not suggest that a loss of twenty-six percent has no significance for sponsor organizations. Studies of the reasons why people leave their organizations should be pursued, and corrective actions, when feasible, should be taken.

Fourth, from the perspective of CIAT efforts to prepare skilled researchers in the focus of its mission and with the purpose of solidly establishing collaborative linkages in CIAT's four specific commodities, the findings of this study on inventories constitute a concern. About half of the persons trained during the period have migrated toward activities different than their fields of training and CIAT commodities.

2. Conjectures on reasons for migration. Why do people leave their organizations, the activity of research, or the specific fields in which they were trained? Several speculative comments are advanced in the following paragraphs about this complex issue. Before advancing any hypothetical explanation, it should be emphasized that these conjectures do not refer to the majority of former CIAT trainees. Most of them, as pointed out in the preceding section, remain in their sponsoring organizations and in the activity of agricultural research. In addition, a proportion of those who are not counted in the inventories may have had to abandon their sponsoring organizations and the activity of agricultural research because of improper professional performance.

From the perspective of social systems which underlies the whole conception of this thesis, human behaviour is determined by the interaction between the desires, expectations, and characteristics of persons, and the structures and cultures of the social systems in which these persons are embedded. Although systems overlap and interact with each other, they are not necessarily convergent in the demands made upon their members. In addition, social systems are not equally responsive to and do not equally fulfill the particular desires and expectations of each of their members. These circumstances generate conflicts within individuals, among individuals, and between individuals and social systems.

How are these conflicts resolved? This is an empirical question for particular settings and persons. With respect to agricultural research, the complexities of the situation may be simplified by reducing the more relevant social systems to three categories: a) the research organization; b) the profession of agricultural research; and c) the primary systems in which the individual's socialization originally took place, e. g., his/her country, local communities, and family.

a. Divergent systems' demands. When the demands of the organization, the profession, and the primary systems are not convergent, agricultural researchers need to make compromises between their loyalties to these systems. They may even have to break their ties with a particular system. For instance, if a professional perceives that the research goals of the organization are irrelevant to the needs of local communities to which he or she expects to make contributions with improved technologies, this researcher may resolve the conflict by leaving the organization and/or the profession, or by lessening his/her ties with local communities.

Conflicts of this nature may be frequent in Latin America, where agricultural research must respond to contradictory demands of dual economies. Conflicting developmental goals often alternate in relative short intervals within the same organization, e. g., the goals of generating technologies to implement national policies of import substitution, exportation of agricultural products, feeding increasing urban populations, or making available technological options for subsistence farms. Some agricultural researchers may have kinship or economic ties to either commercial or subsistence agriculture which bring these conflicts to critical points. Crises may be resolved by leaving the organization or the profession. An alternative route in the resolution of this type of conflict is to strengthen the loyalties to the organization or the profession, and to decrease the importance of developmental goals. This option may imply, for instance, dwindling researchers' ties with local communities. A consequence may be diminished relevance of researchers' technological outcomes to the problems of the compromised social system, e. g., communities of farmers who practice subsistence agriculture.

The demands of different social systems upon agricultural researchers may act as counterveiling forces. What may be dysfunctional for researchers' role performance is the total orientation toward a given social system with exclusion of the others. For instance, a total orientation toward the profession may result in research outcomes lacking relevance to organizational goals and agricultural development needs; a total orientation toward the organization may lead researchers to concentrate on the goal of getting the highest positions of the bureaucratic hierarchies with the result of losing continuity in their research work;

and, a total orientation toward the farmer without taking into consideration the needed loyalties to the organization and the profession may result in researchers who understand very well their clientele needs but do not have the research support provided by the organization, and the knowledge basis generated by other colleagues.

b. Difficulties in making a living. From the personal side, researchers have their own needs, aspirations, and expectations, in the whole range from physiological primary requirements to social psychological and cultural needs, such as belonging, identity, self-esteem, and creativity.

In reciprocity for their work, researchers expect to make a decent living from the practice of their profession and their loyalty to a given organization. When agricultural researchers realize that by staying in their organizations and professions they cannot afford to have adequate housing, food, clothing, medical services, education, and recreation for themselves and their families, they will probably be compelled to move toward other activities and organizations. Sometimes what makes a researcher leave his/her organization or profession is a prospect of a better education for his/her children, or a minimum additional facility, e. g., the opportunity to have a vehicle for personal and family use.

An alternative that seems to be emerging in several countries is the engagement of agricultural researchers in small businesses parallel to their work at a given organization. In some cases this option takes place through ownership of a small farm or growing of a cash crop on rented land. These income earning activities are not always well accepted by administrators of agricultural research organizations, because by doing that professionals may demphasize their research commitment to

their work. This course of action, however, may have indirect but unplanned advantages; carrying out crop production gives researchers opportunities to test in real conditions the technologies they recommend to farmers, and to be aware first hand of the need to modify those technologies according to local bio-physical, economic, and cultural environments.

Salaries and other economic compensations for agricultural researchers in Latin America are very restricted. One reason for this is the general stage of development of national economies. Another is the relatively low status in any country of agricultural activities. Other factors relate to organizational constraints, such as very limited budgets and rigid administrative procedures. Many administrators of Latin American agricultural research organizations are conscious of the need of improving the economic conditions of researchers. Administrators may be willing to take these actions, yet find obstacles in doing it. Most agricultural research in Latin America takes place in governmental agencies: ministries, research institutes--where bureaucratic practices usually do not permit compensation to a creative person for their work in correspondence with their contributions and accomplishments, but on the basis of narrowly fixed criteria which apply uniformly to all public servants in a specific status position within the hierarchy. When a given researcher finds better job conditions than those of the organization or the activity of research, administrators do not usually have a realistic option but to accept with regret the departure of qualified and talented members of the organization.

c. Personal professional development. It is entirely legitimate according to the norms of the system of science for a person to seek personal development as a member of a given profession. Furthermore, in the case of agricultural research in Latin America, this seems highly desirable for the long run institutionalization of S&T as an internal capability of these societies.

d. Training and formal education. The population of this study is composed of relatively young persons, many of them in their first job and just starting careers as agricultural researchers. They need opportunities to pursue their training and formal education at higher levels, e. g., participation in workshops, seminars, conferences, and other professional meetings, M. S. and Ph. D. studies, postdoctoral appointments, sabbatical leaves, and so on. When researchers perceive that in other organizations they will have better training and educational opportunities, it is very likely that more venturesome researchers will try to move there.

e. A research career. The vigorous pursuit of a productive professional career requires not only training, formal education, and degrees. It requires the recurrent engaging in research on problems which are significant for oneself and for others to whom one regards as significant colleagues. Implicit in this fulfilling of a research career are i) the opportunities to develop a long term commitment to specific fields of research, ii) the availability of a minimum level of resources and support for carrying out research in those fields, and iii) open possibilities for acquiring an identity as a member of a self-generating community of researchers.

i. Long-term commitments. Opportunities for developing long term commitments to specific research fields may be restrained in the environments of Latin American agricultural research, because of compounded effects of the conceptions and values held at the societal level with respect to scientific activities, and interferences of bureaucratic mandates.

On an abstract level, it is very likely that S&T endeavors are highly valued by most sectors of Latin American societies. Nevertheless, these abstract valuations may result in mainly idealized conceptions of scientific activities without sensitivity to the conditions that enable them to occur. Perhaps the more concrete images of S&T in Latin America are associated with labs, sophisticated equipment, computers, journals, books, and libraries, surrounding eminent scholars. What is observable by outsiders about the actual work of an agricultural researcher is not the creative individual and the collective intellectual processes, but the physical activities inherent in agricultural research. The daily routines of a middle level agricultural researcher who spends most of his time planting, growing and harvesting crops might be regarded as too prosaic a set of tasks to fit in the idealized conception of science. Consequently, people--particularly decision makers at the national level--could wonder why they should give much thought and attention to the long-term commitments of a professional career of a number of public servants whose more visible activities are traveling in a jeep and making visits to crop fields. Ironically, the idealized conception of science may lead to very simplistic understandings of research work. Continuity of research may be considered as identical to continuity in a job, ignoring that what matters in scientific research is not the inherent physical activities,

but a set of cognitive and social processes. These are the processes by which a person internalizes specific research concerns; keeps aware of past and current work done in the field; creates and tests images about empirical relationships, elaborates conceptual frameworks; engages in collaborative work with others interested in similar or related cognitive goals; shares approaches, findings, interpretations, assessments, and accomplishments with significant colleagues; and, in so doing, contributes to the building of S&T. These cognitive and social processes take time. Without open opportunities for researchers to engage in long-term commitments to specific fields of research, these cognitive and social processes are not likely to develop.

Long-term commitments may be hampered by bureaucratic mandates which obligate researchers to switch from one research problem or field to another; there are occasions when those problems and/or fields may be totally unconnected. The emphasis here is not with autonomy of professionals in the selection of research problems, although intellectual freedom is also an important factor in the pursuing of a scientific career. By its very nature, agricultural research is expected to make important contributions to socio-economic development in LDC's; this reality implies that, in self-conscious selecting of cognitive goals, researchers need to make compromises with their personal preferences and with the dominant concerns within their professions. However, what cannot be compromised, if research effectiveness is desired, is continuity in the pursuit of a research goal. Managerial mandates which obstruct continuity frequently emerge not as purposive will to interfere with research, but as the result of a diversity of political and economic pressures from interrelated social systems. There are cases in which researchers seem to be

equated with computers which are fed instructions and data, and are expected to immediately give out the desired information. This "computerized" image of a researcher does not take into account the social-psychological and cultural forces involved in becoming a creative researcher. Unfortunately, continuity of research--which is one of the main functions a formal organization of research is expected to maintain--is sometimes disrupted by managerial practices. Perceived lack of opportunities for having continuity in research may induce professionals to abandon their organizations and/or the activity of research.

ii. Research resources and support. Here is where research organizations are expected to play a substantive role in the institutionalization of S&T. Organizations constitute a fundamental infrastructure for the activity of research. They provide a home, a collective identity, and resources, so researchers can work with support, security, and continuity.

There is much heterogeneity in the level of development of research organizations in Latin America. The range goes from no existence of organizations expressly designed for research in some countries to complex systems of local, state, and national research centers (such as EMBRAPA in Brazil).

This heterogeneity makes one expect that there is a relationship between researchers' behaviour and the level of research facilities. In contrast to this expectation, this study disclosed no statistically significant difference to support this belief. As pointed out in chapter four, this lack of statistically significant differences may be due to the gross categories used in the comparisons. The consideration

that most agricultural research is a non-capital intensive activity, and that most members of the sample studied have at their disposal at least the minimum requirements of resources for conducting research may explain the lack of statistical differences in the variable research support facilities.

There are more subtle aspects of research support that may stimulate migration: a) unrealistic expectations from research administrators and segments of a society about project datelines, or about the quality and quantity of research outcomes; these expectations may reflect lack of understanding of the uncertainties inherent in research and can take the form of very short-term planning and/or inadequate reserch implementation; b) hidden organizational policies against the building of professional careers in agriculture; c) perception by researchers that they and their work are not held in esteem in their organizations, profession, countries, or local communities;) political influences over professional appointments and promotions; d) lack of identity of researchers with the product of their work and/or loss of intellectual property; f) lack of a communication environment which facilitates interaction among colleagues; and g) perception by agricultural researchers that they lack a feeling of self-confidence and security as members of their organizations and professions.

iii. Self-supporting communities of researchers. A factor which appears not to be well recognized for facilitating the building of research careers is the existence and possibility of participation

in self-supporting communities of researchers. This topic refers to the researchers' networks. Interpretations of the findings on networks are the substance of the following section.

3. Interpreting findings on research networks. Three questions of the social structures and third cultures created, maintained, and shared by this segments of Latin American agriculturists are especially noteworthy: a) how do these linkages arise, grow, and develop?, b) what are the uses and purposes of these networks?, and c) why do these research communities arise, grow, and develop?

a. How do linkages emerge and evolve? This section attempts to speculate about the process of research network development (RND). The arousal of nascent linkages may presumably begin in a diversity of occasions. For instance, some links are established very early in the life of a person as member of primary systems; these include kinship, religious, local community, first schooling, and other kind of ties.

A substantive number of interpersonal links among middle level agricultural researchers in Latin America are created during the B. S. studies with teachers and peers. However, many of these connections do not evolve; they remain latent or eventually fall apart. This, in particular, may be the case of latent or no significant ties with former B. S. teachers, who in most Latin American organizations of agricultural education do not have adequate opportunities and rewards for pursuing research endeavors.

Probably a high proportion of ties which become intensive are created when practitioners are in the process of entering

specialized fields of research, and when they are trying to keep themselves up-to-date on the developments of their current fields of specialized work. This may occur during postgraduate studies, but for this particular sample, many of what eventually evolved as intensive ties are relationships that were initiated with instructors and fellow students during training programs at CIAT for entering specialized fields of research. Ties established with former professors at the Master and PhD level are highly influential, often resulting in deep interchanges, but are low in the frequency of interactions (intensive sub-type one) and in the number of persons engaged. The low frequency might be attributed to lack of a facilitative communication environment for making interchanges feasible, but the evidence gained in this study in this respect is mixed. The low number of people engaged in intensive interchanges with former professors at the Master of PhD level is explained by the fact that most members of this study population do not undertake postgraduate studies.

Some links emerge from literature reviews when a professional becomes aware of the existence of persons conducting significant work in his/her field of interest, makes the decision of trying to contact those colleagues, has the opportunity to do it, and finds reciprocity in some of them. Other connections are established at the moment of entering a new organization of research, in the planning and executing of inter-organizational formal contracts for conducting coordinated research, during the interaction with consultants, and at professional meetings.

The number of research groups identified in this study, and the fact that most of them are specialized, supports the conception that

what brings these people together is the sharing of their cognitive goals and experiences, that is, their research problems and findings. The point of departure for starting the building of functional linkages with significant colleagues is, then, the awareness by practitioners of the existence of other researchers who have similar cognitive interests to theirs.

A second step is the acquaintance with the researchers personally and with the work they have completed or that is in progress. This is done through face-to-face encounters, by correspondence, or by studying published work. At the level of acquaintance, in addition to knowing work characteristics, practitioners learn about each other's national, organizational, and professional identities. Availability of directories of researchers with names, organizational affiliations, current addresses, and indications about work interests facilitate these processes of awareness and acquaintance. This is the level that Miller (1975) calls socio-cultural in the development of an interpersonal relationship. Nascent ties are typically at this level.

Additional and continued interactions allow researchers not only to learn more about each other's work activities and interests, but to get insights about each other's personalities. Then relationships become established at a more psychological level. Nascent ties start transforming into intensive linkages. Functional interchanges for work activities and for personal support begin to appear.

As interchanges gain frequency and depth, inconsistencies among practitioners' conceptions of research work may emerge. These inconsistencies are frequently identified with communication barriers, such as problems in terminology, imcompatible personalities, lack of

communication skills, negative attitudes toward team work, or excessive individualism on the part of some researchers. However, communication difficulties are only symptoms; these inconsistencies reflect deeper philosophical disagreements about the whole conception and practice of scientific research; disagreements which often materialize as conflicting views on research priorities, approaches, and techniques. As a result, at this stage ties may decay and extinguish or stay at a latent level.

These disagreements are not mere confrontations of personalized views and individualized patterns of behavior. They arise from differing views predominant in segments of the larger social structures and cultures in which researchers are embedded, and with which they identify themselves, e.g., the profession, the organization, sectors of the economy, political parties, nationalistic views, and so on.

An intense and open debate or submission on the part of maintainers of the conflicting views is required so a minimum of consensus can begin to emerge among members of the research network. An example of these types of conflicts has existed for several years among sectors of this study sample in the fields of rice and beans. In rice the central issue has been the generation of appropriate technologies for farmers who produce rice under non-irrigated conditions; in beans a recurrent debate is the generation of appropriate technologies for small farming, particularly in reference to crop associations between beans and other compatible species.

Interpersonal relationships which survive these confrontations and continue to be intensive gain endurance and functionality. "Invisible colleges" begin to be structured by those practitioners who have not only a common cognitive focus in their research interests, but who

share views about the relevant priorities and the appropriate ways of conducting research in their specialized fields.

At this stage, collaboration in research ceases to be an abstract aim, and starts to be translated into concrete sets of concerted activities. Well structured research groups come to exert leadership and influence within their fields. Up to this point, a community of researchers is no longer a metaphor, but a viable, concrete, self-supporting entity whose existence and continuity of operation represents a solid step in the institutionalization of S&T in a given society or in a set of inter-dependent societies.

At all stages in the devolopment of a research network links continue to emerge and transform. Some of them become intensive, others decay and stay latent or even disappear. In turn some latent links may be activated by new research opportunities and events among members of the research network. A high proportion of extinction of intensive ties may indicate the decline of the entire research paradigm as a consequence of drastic internal and/or external changes.

b. The uses and purposes of these research networks. The content of research interchanges mentioned by the sample members interviewed give origin to a long list from which the uses and purposes of these networks can be inferred. These uses and purposes are summarized in two sets: practitioners engage in network interchanges to obtain i) research resources, and ii) socio-psychological support.

i) Resources. There is a variety of research resources that practitioners with nascent and intensive ties interchange: materials, particularly plant germ plasm; services, especially lab analyses and data processing; information about research sponsors; names and

addresses of other colleagues in the field; and published research literature (it seems that many people get access to the relevant literature more by personal contacts than through libraries).

Other resources are interchanged mainly by members of invisible colleges: pre-prints, most of the time asking for comments and suggestions; raw data about experiments and field observations which are just finished, but for which analysis and interpretations has not been completed by the investigator; interpretation and assessment of findings; and views about research priorities and approaches.

An item of particular importance in the more intensive interchanges among members of research groups is what may be designated as interchange of work. More active members of these research networks sometimes engage in collaborative personal research agreements in which an experiment is replicated by different practitioners with differing organizational affiliations and, on occasions, working in different countries.

ii) Socio-psychological support. The category called here socio-psychological support is perhaps what keeps these sets of people together and makes possible the development of social structures and cultures which eventually emerge as identifiable communities of researchers. Socio-psychological support at the beginning of a relationship--when links are still at a nascent stage or starting to gain intensity--consists of help provided by more mature researchers to new entrants. In many cases this type of support is given by helping new practitioners identify training, educational, and career opportunities; providing letters of recommendation for entering graduate schools; helping secure funds and invitations for participation in professional meetings, local,

national, and international; instructing about where and how to apply for scholarships and assistantships; and helping newcomers develop their own personal identities as practitioners of particular fields of research.

At subsequent stages of development of these interpersonal relationships, socio-psychological support implies some degree of mutual reliance; more mature researchers take the risks involved in recommending fellow researchers for job appointments in places where those more mature persons have achieved prestige. A recommendation for a research position means much more to a practitioner than an employment opportunity; it means that the one who is recommending him/her is showing a signal of respect and appreciation; recipients of this type of social-psychological support feel that they are held in esteem by people in what they start to consider "their" fields of research.

Finally, more developed linkages--typical of invisible colleges--are both highly professional and highly personalized. At this stage the interpersonal support implies high reciprocity, and it is characterized by the presence of a strong social-psychological factor, which in Spanish is well described by the word "confianza." "Confianza" implies more than reliance and confidence; perhaps "trust" is its equivalent in the English language. Trust among fellow researchers opens opportunities for them for interchanging specifics about research approaches and techniques that they use, although these techniques and approaches are still not widely accepted or standardized; opportunities arise for interchanging details of projects which failed; details about what would be considered "negative" results if published; about problems and confrontations with research administrators and politicians; about forthcoming opportunities perceived as promising in the field or in

neighboring fields; about projects in the fields perceived as very risky undertakings; and, particularly, about philosophical views on what should and should not be research priorities in their specialized fields. However, trust in the interpersonal relationships among members of research networks does not imply a blind loyalty which avoids objectivity in pointing out the professional concerns with each other's research activities and outcomes. Researchers who trust each other openly analyze their work and make competent criticisms about it; but those interchanges are personalized, and remain among the interactants who trust in each other's loyalties, so this type of information will not be used against any one of them in the profession, in their organization, or in their other social milieus.

c. Why do these research communities arise and develop? Four sources of explanations are presented in the following paragraphs in relation to the emergence and development of research networks: i) dysfunctionalities in the formal structures; ii) the nature of some research goals which are inherently transorganizational and transnational; iii) costs and economies of scale and size; and iv) risks and uncertainties inherent to scientific research.

i) Dysfunctionalities. At the intra-organizational level, the emergence of non-formalized structures may be associated with dysfunctionalities in the distribution of power, influence, and resources through the formal organization chart; or the organigram may seem adequate but for some reason it simply does not work. This seems to be the case in some Latin American organizations of agricultural research having a highly structured distribution of positions from the national to the local level. These structures usually establish as "link pins" between the

central hierarchy and the research teams at the local level a set of "national coordinators" (the equivalent of "liaisons" in the research networks) who are not always adequately equipped with the necessary budgetary flexibility to operate, or lack formal authority to "coordinate" research activities and projects.

Dysfunctionalities of the formal structures in research organizations are a complex difficulty, which involves more than simply systematic arrangements of positions and job descriptions. Recently, Theodore W. Schultz (1979) has pointed out how the entrepreneurial function, which is responsible for the dynamics of innovation and progress in society, operates differently in businesses and research organizations. In business enterprises, the centralized body of high level executive officers performs the entrepreneurial function, while the skilled factory workers do the unchanging, routine tasks. But research is otherwise. Administrators may be entrepreneurs in fostering the organizational infrastructure for research activities but the dynamics of innovation and progress in the specialized fields of research is beyond administrators' possibilities. Research entrepreneurship is the function of the research worker. A critical question concerning the design of formal organizations of research, then, is: To what extent is it viable and advisable to "coordinate" by mandatory acts? In the words of Professor Schultz:

> The convenient assumption is that a highly organized research institution firmly controlled by an administrator will perform this important function. But in fact a large organization that is tightly controlled is the death of creative research, regardless of whether it be the National Science Foundation, a government agency, a large private foundation, or a large, research-oriented university (Schultz, 1979, p. 7).

Dysfunctionalities in formal structures of research, in addition, may relate to lack of or weak mechanisms for providing adequate recompensations to researchers for their work and accomplishments. Another important component of this problematic situation is related to the extent to which the formal organization has adequate mechanisms for the allocation of professional recognition and rewards to its research workers. As pointed out by Swanson (1975, quoted on p. 75), on occasions researchers in Latin American organizations of agricultural research lose their identities in their work. This loss of identity sometimes occurs as the result of very limited availability of channels for publishing research findings. There are organizations in which the annual report constitutes almost the only channel available. As a general practice, most annual reports do not associate the work reported with any person in particular. Practitioners involved in these situations feel that they are not held in esteem by their organizations. Interpersonal relationships with significant colleagues may be regarded as a substitute for the social-psychological support that their organizations are failing to provide them.

Beyond the boundaries of organizations, at the country, region, and worldwide levels, dysfunctionalities in formal structures which stimulate the emergence of research networks may be related particularly to lack of active professional associations, lack of or weak formal communication systems of science, and lack of accessibility of these sample researchers to the international journals of the world epicenters of science. These journals may have very low priority for publishing the type of outcomes generated by these practitioners, which are for the most part adaptations of previously generated technologies.

ii) The nature of research goals. This is another possible explanation causing high networking activity. There are research concerns which transcend the boundaries of a particular organization, local community, country, and even region. This seems to be the case of practitioners engaged in research in rice and tropical pastures.

iii) Costs. Related to the above-mentioned factor is the issue of research projects which may be extremely costly if performed by a single organization or country, but may be jointly pursued by members of different organizations who are already scattered through wide geographical regions and in a diversity of ecological conditions.

iv) Risk and uncertainty. In its own essence research is a human enterprise conducted under conditions of high risk and uncertainty. As pointed out elsewhere, researchers may not be willing to share their uncertainties with formally appointed research leaders in their organizations, because this information could be used against researchers' professional and bureaucratic careers. So they do not trust in the formal structures to reduce the psychological stresses and tensions induced by the inherent uncertainties and risks of their research projects. Consequently, they develop interpersonal relationships deep enough so they can trust and receive personalized understanding and support from others who have experienced similar risks and uncertainties.

4. Non-participation. This last part of the chapter turns the attention to the phenomenon of non-participation. Two aspects are interpreted: a) why a proportion of research practitioners do not participate in these communities, and b) What may be some consequences of non-participation?

a. Why people do not participate. This is a much more speculative section than the preceding, because non-participants have not been interviewed for this study. Before presenting a series of possible reasons for non-participation a methodological note related to the quantification of non-participation is introduced here as a kind of brief digression.

The number of persons who do not participate in networks of researchers (sixty-six out of the 207 in the sample of this particular study) suggests an extended pattern of isolation for subsectors of the population. However, the magnitude of non-participation may only be apparent, given that a large portion of the population is not included in this analysis (p. 146). It is possible that the extent of non-participation is lower in the population than in the sample. The reason is that non-participants in the presence of more respondents may receive nominations, increasing their linkage in that way. Depending on the intensity of such connections, non-participants might emerge, in reclassification, as participants. The highest change in this respect may occur in tropical pastures, which shows 45% of respondents identified as non-participants. The opposite may also occur. The 207 questionnaires included in the analysis correspond to the earlier respondents. A bias could exist associated to response of questionnaires. For instance, delay in responding could be positively correlated with non-participation. Therefore, if this be the case, the addition of more respondents to the analysis probably would increase the proportion of non-participants.

Returning to factors likely to be associated with non-participation, the following is a list of possibilities. Under the assumption that non-participation is relatively high (about one third

in this study sample) the first reason may be lack of a facilitative communication environment. This includes lack of actualized directories of persons in the research fields surveyed, low activity of professional associations within countries and in the region, organizational policies consciously or unconsciously militating against research interchanges among colleagues, lack of funds for traveling or using telephone and mail systems, mail system difficulties, and visa problems, among others.

Additional reasons for non-participation in networks of researchers may include: personality characteristics of some researchers who prefer work and stay in relative isolation, excessive nationalism of some researchers who regard with suspicion the transnational activities involved in networking, ideologies in conflict with international collaboration and with a view of inter-dependence among nations, patterns of authoritarianism and dogmatism perceived by some non-participant researchers as predominating among groups of very active colleagues, excessive competence in some fields (which may result in patterns of secrecy), excessive bureaucratization which frustrates any attempt to participate in professional meetings, and fields composed of "one-of-a-kind" researchers (that is, fields where a "critical mass" of colleagues still has not developed).

b. Consequences of non-participation. Several possible consequences may result from non-participation. First, lack of contribution to S&T. As pointed out by Goulet (1975), S&T activities normally occur in a collective social context. Non-participants, as defined in this study, are not transmitting by personalized interchanges the research findings to the mainstream of colleagues. Accordingly, unless non-participants publish their findings in the formal system of communication--

journals, books, etc.--their isolation deprives their scientific communities of their contributions. Given that most members of this study population are young professionals in the first stages of their research careers, and given the limited number of journals and scientific publications available in Latin America, it is very likely that the research findings of non-participants are not accessible to their colleagues.

Second, S&T obsolescence. Non-participation in networks of relevant researchers could also be interpreted as suggesting that a segment of former CIAT trainees may be unaware of the technical progress that their research associates are achieving in research endeavors pertinent to theirs. Such isolation may result in rapid obsolescence of previous training.

Third, S&T lag. Non-participants may be getting access to the S&T progress through the formal communication system, via printed and other media. This system is not consistently characterized by speed. While its better performed functions are giving professional recognition, assessment, and permanence to scientific advances, the last issue of a scientific journal often reports research carried out and findings obtained several years ago. In addition, the formal system is not commonly the best way to get full access to the specifics of research technology. Fine descriptions of research instruments, techniques, and procedures are usually not published in scientific journals, but typically diffuse via personalized interchanges among colleagues. This is particularly the case in applied agricultural sciences. In most applied fields much of the flow of knowledge comes not through formally published books and journals, but through correspondence, pre-prints,

mimeographs, findings, and data, which circulate by personalized interchanges. Researchers in rapidly growing fields, who rely entirely on journals and books for their information may confine themselves by continually lagging behind in scientific knowledge.

Fourth, cultural dependence. One consequence of over-relying on established international journals and books published in the world epicenters of science is cultural dependence. Latin America still has not developed an adequate formal system of scientific communication. Consequently, most literature comes from other cultures. A mere consumerism of foreign scientific literature does not provide a full opportunity for entering in the creative process of interaction between cultures, which results in the development of third cultures of science and technology. An over-dependency on the foreign scientific literature can impede the generation of indigenous capabilities for S&T in the region.

Fifth, lack of identity as practitioners of research. Non-participants who cannot get recognition and rewards through the formal communication system, and who--by definition of non-participation--do not receive personalized socio-psychological support, respect and esteem, are open to disillusionment in their research activities which, added to other consequences of isolation, might precipitate migration of non-participants toward activities other than research. Non-participation and propensity to migrate from research might be two inter-dependent factors which reinforce each other through time.

In summary, non-participation in networks of researchers is regarded in this study as a symptom of scientific isolation. And isolation might be impinging on the broader aims of encouraging task

forces of researchers to contribute to agricultural development in particular, and to the institutionalization of S&T in general.

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APPENDICES

APPENDIX A

Letter of the Director General of CIAT for legitimizing the study and the investigator, and for sending the census formats.

Centro Internacional de Agricultura Tropical
CIAT
Apartado Aéreo 6713
Cali - Colombia

Desde sus inicios el CIAT ha venido desarrollando una activa labor de apoyo a la preparación y actualización de investigadores agrícolas en América Latina por medio del entrenamiento postgrado.

Ahora deseamos hacer una revisión sistemática de nuestros esfuerzos de entrenamiento en investigación, con el propósito de identificar si es necesario introducir cambios que hagan este entrenamiento más significativo para los profesionales, y especialmente más útil para los programas de investigación que usted dirige.

Con tal fin vamos a realizar un estudio que incluye tres fases de recolección de datos: 1) el cuestionario que adjuntamos a esta carta, cuyo objetivo es determinar la población del estudio; 2) un cuestionario que será enviado subsecuentemente a todos los profesionales que han estado vinculados a la investigación después de su entrenamiento en CIAT; y 3) entrevistas con algunos de esos mismos profesionales. Las entrevistas serán llevadas a cabo por el investigador principal del estudio Ing. Jairo Cano. Se espera que los resultados estén listos a mediados de 1981, época en la cual haremos llegar a usted un resumen del mismo.

El éxito del estudio depende en gran medida del apoyo que usted nos brinde. Al efecto quiero solicitarle que nos suministre la información relativa al cuestionario que le estamos haciendo llegar con esta carta. Le anticipo mis agradecimientos por su valiosa ayuda y le reitero nuestro agrado en continuar colaborando con su institución.

Atentamente,

JOHN L. NICKEL
Director General

APPENDIX B

Census instructions.

Centro Internacional de Agricultura Tropical
Apartado Aéreo 6713
Cali - Colombia

Estudio del entrenamiento en investigación, CIAT

Apreciado señor:

Por favor infórmenos acerca del profesional cuyo nombre aparece encabezando cada tabla. Deseamos obtener los siguientes datos para el período posterior a su entrenamiento en CIAT:

a. Si este profesional ha trabajado en la institución que usted dirige, aunque su actividad no haya estado relacionada con la investigación (punto 1 en la tabla).

b. Si este profesional ha trabajado en investigación en una de las siguientes especies: arroz, fríjol, pastos tropicales y yuca (puntos 2-5 en la tabla).

c. Si este profesional ha trabajado en actividades relacionadas con la investigación aunque no haya sido en las especies mencionadas antes (punto 6 en la tabla).

Usted puede darnos los datos del caso simplemente haciendo una marca (/) en la celda correspondiente a cada pregunta y año para los cuales la respuesta sea positiva. Para reducir posibles confusiones hemos hecho las siguientes definiciones, las cuales le rogamos leer antes de llenar las tablas.

Definiciones:

1. Trabajó en el año X: Significa que el profesional trabajó al menos parte de ese año en lo indicado por la pregunta (su institución, arroz, fríjol, pastos tropicales, yuca o en investigación en general).

2. Trabajó en su institución: Significa que el profesional trabajó en ese año para su institución, bien sea en investigación o en cualquiera otra actividad.

3. Trabajó en investigación en general: Significa que el profesional trabajó en una o varias de las siguientes actividades en relación con cualquier tipo de investigación:

(Sigue al reverso)

a. Como investigador, aunque no haya tenido que ver con las cuatro especies mencionadas en la tabla.

b. Como instructor de otros investigadores.

c. Como administrador para dar apoyo a la investigación.

d. Como consultor acerca de asuntos relacionados con la investigación.

Ejemplo: Supongamos que el profesional Luís Rodríguez estuvo en CIAT en 1974 participando en entrenamiento. Regresó a su institución y trabajó el resto de 1974, 1975 y 1976 como investigador en fríjol. En 1977 ocupó una posición administrativa dando apoyo a la investigación. En 1978 y 1979 permaneció en la institución pero se dedicó a actividades no relacionadas con la investigación. Los datos correspondientes a este profesional se anotan en la tabla así:

LUIS RODRIGUEZ (1974)

Trabajó en el año	69	70	71	72	73	74	75	76	77	78	79
1) en esta institución						✓	✓	✓	✓	✓	✓
2) como investigador en ARROZ											
3) como investigador en FRIJOL						✓	✓	✓			
4) como investigador en PASTOS											
5) como investigador en YUCA											
6) en investigación en general						✓	✓	✓	✓		

a. /___/ carecemos por completo de información acerca de este profesional.

b. Otras observaciones:

Es posible que algunos profesionales no hayan regresado a su institución después del entrenamiento en CIAT, o que después de algunos años pasaron a otras instituciones. Si usted está informado acerca de ellos por favor complete las tablas respectivas. En caso de que carezca por completo de información acerca de ese profesonal, indíquelo en el espacio correspondiente al pié de cada tabla.

A continuación le adjuntamos la lista de profesionales de su institución que participaron en cursos de entrenamiento en CIAT:

APPENDIX C

1. Letter to send the network questionnaire.
2. Network questionnaire

Centro Internacional de Agricultura Tropical
CIAT
Apartado Aéreo 6713
Cali - Colombia

Desde sus inicios el CIAT ha venido desarrollando una activa labor de apoyo a la preparación y actualización de investigadores agrícolas en América Latina por medio del entrenamiento postgrado.

Ahora deseamos hacer una revisión sistemática de nuestros esfuerzos de entrenamiento en investigación, con el propósito de identificar si es necesario introducir cambios que hagan este entrenamiento más significativo para los profesionales y las instituciones que se dedican a la investigación agrícola en América Latina.

Con tal fin estamos realizando un estudio que incluye tres fases de recolección de datos: 1) un cuestionario que ya fue enviado a las instituciones, cuyo objetivo es determinar la población del estudio; 2) el cuestionario adjunto que estamos enviando a usted y a todos los profesionales que han estado vinculados a la investigación después de su entrenamiento en CIAT; y 3) entrevistas con algunos de ustedes. Las entrevistas serán llevadas a cabo por el investigador principal del estudio Ing. Jairo Cano. Se espera que los resultados estén listos a mediados de 1981.

En busca de su valiosa ayuda queremos solicitarle que responda el cuestionario y nos lo envíe de regreso. Las respuestas de cada persona se mantendrán estrictamente confidenciales por el investigador principal quien será la única persona con acceso a los datos. Estos serán procesados en forma agregada, de tal manera que las respuestas finalmente serán presentadas en términos de promedios, porcentajes y otros estadísticos. No se harán comparaciones que permitan identificar a personas o instituciones.

Deseamos insistir en la importancia que para el planeamiento de las futuras actividades de entrenamiento en CIAT tiene la información que usted nos proporcione. Contamos con que usted nos brindará tan valiosa cooperación.

Atentamente,

Jairo Cano,
Investigador Principal
Michigan State University

p/

Fernando Fernández
Coordinador, Entrenamiento
Postgraduado, CIAT.

Cuestionario No. 2

PREGUNTA 1. SU PARTICIPACION EN INTERCAMBIO DE INVESTIGACION CON SUS COLEGAS

Deseamos conocer su participación en intercambio de investigación con otros colegas que están trabajando en su campo profesional. Tal información nos permitirá explorar la formación de redes de personas que comparten sus intereses y recursos en investigación agrícola en América Latina.

Permítanos conocer los nombres de las personas con quienes usted SERIAMENTE intercambia investigación. Deseamos mantener tales nombres separados a cuatro niveles: Dentro de su institución, su país, América Latina, y el mundo. Por favor indíquenos con qué frecuencia y profundidad tiene usted tales intercambios.

Por intercambio de investigación estamos designando no sólo el intercambio de ideas acerca de problemas y metodologías de investigación, sino también el hecho de compartir otros recursos tales como especímenes (por ejemplo, germoplasma), acceso a servicios de equipo y laboratorio, u otros recursos significativos para llevar a cabo investigación.

Usted puede darnos una indicación de la frecuencia de sus intercambios de investigación al señalar una de las siguientes dos categorías: FRECUENTE, POCO FRECUENTE. Por "frecuente" queremos decir varias veces durante un año. Por "poco frecuente" queremos decir una vez por año o menos. Usted puede indicarnos la profundidad de sus discusiones e intercambios chequeando una de dos categorías: PROFUNDO, SUPERFICIAL. Para anotar su información utilice la tabla 1 que está en la siguiente página. En la parte superior de la tabla usted encontrará un ejemplo.

PRIMER NIVEL: SU INSTITUCION. Empiece con su institución u organización. Por favor anote los nombres de las personas con quienes usted SERIAMENTE intercambia puntos de vista y recursos acerca de su trabajo de investigación. Si no hay ninguna persona, escriba en la columna de nombres: "Nadie de mi institución". Antes de seguir al nivel de país, trace una línea bajo el último nombre que usted escribió o bajo la frase "Nadie en mi institución" si ese es el caso.

SEGUNDO: SU PAIS. Por favor continúe a nivel de su país, pero fuera de su institución. Si no existe ninguna persona, escriba "Nadie de mi país" y trace una línea como lo hizo antes para mantener los niveles separados.

TERCERO: AMERICA LATINA. Continúe al nivel de América Latina, pero fuera de su país. Si no existe ninguna persona, escriba "Nadie de América Latina". Por favor, una vez más trace una línea para mantener los niveles separados.

CUARTO: EL RESTO DEL MUNDO. Finalmente, indique sus intercambios con investigadores del resto del mundo, pero fuera de América Latina. Si no existe alguno, escriba "Nadie del resto del mundo".

Tabla 1. Espacio para anotar la información acerca de sus intercambios de investigación. Ejemplo: Alguien de ICTA, Guatemala, está respondiendo esta pregunta y mantiene intercambio dentro del ICTA con un investigador hipotético cuyo nombre es LUIS RODRIGUEZ. Bajo la suposición de que tales intercambios son poco frecuentes y profundos, la información se anotará de la siguiente manera:

NOMBRES	INSTITUCIONES	PAISES	Mis Intercambios de Investigación con esta Persona son: Frecuencia: Frecuentes	Frecuencia: Poco frecuentes	Profundidad: Profundos	Profundidad: Superficiales
LUIS RODRIGUEZ	ICTA	GUATEMALA	2	(1)	(2)	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1
			2	1	2	1

(Espacio adicional al reselde)

PREGUNTA 2. LA DISTRIBUCION DE SU TIEMPO DE TRABAJO

En términos de la posición que usted ocupó **inmediatamente después** de su participación en entrenamiento en CIAT, por favor díganos cómo distribuyó su tiempo de trabajo durante aquel año entre las actividades profesionales que se señalan más abajo. Dénos sus respuestas en porcentajes:

Actividades **Por ciento**

a. Haciendo investigación..... _____%___

b. En actividades de apoyo a la investigación (administración, consultoría, entrenamiento, operaciones de campo, documentación, u otra similar)..... _____%___

c. En actividades NO RELACIONADAS directamente con investigación ..... _____%___

Por favor, revise las cifras que acaba de escribir y asegúrese de que suman en total 100%.

PREGUNTA 3. EVALUACION DE SU DESEMPEÑO PROFESIONAL

Por favor evalúe su propio desempeño profesional en investigación durante el año **inmediatamente después** de su participación en entrenamiento en CIAT. ENCIERRE CON UN CIRCULO el número que en su opinión describe mejor su desempeño profesional, de acuerdo a la siguiente escala:

0 = No es mi caso pues no desempeñé este tipo de actividad.
1 = Entre los más bajos en comparación con el personal profesional de mi institución en ese año.
2 = Bastante bajo.
3 = Promedio.
4 = Bastante alto.
5 = Entre los más altos.

	No es mi caso	Entre los más bajos	Bastante bajo	Promedio	Bastante alto	Entre los más altos
a. Mi desempeño profesional como investigador.....	0	1	2	3	4	5
b. Mi desempeño profesional en actividades de apoyo a la investigación (administración, consultoría, entrenamiento, operaciones de campo, documentación, u otra similar).....	0	1	2	3	4	5
c. En actividades NO RELACIONADAS directamente con investigación.....	0	1	2	3	4	5

PREGUNTA 4. SUS DATOS PERSONALES

a. Nombre: _____

b. Institución donde trabaja actualmente: _____

c. País: _____

d. Número de años de experiencia en investigación: _____

e. Area(s) de investigación:

☐ Arroz ☐ Frijol ☐ Pastos ☐ Yuca

☐ Otra(s). Por favor, indique cuál(es): _____

_____

GRACIAS POR SU COOPERACION

APPENDIX D

General data about CIAT training program.

Table D-1. Total number of former CIAT trainees distributed by geographical regions of the world. *

Region	N	%
Africa, Asia and Australia	65	4.6
North America and Europe	89	6.3
Latin America	1259	89.1
TOTAL	1413	100.0

Table D-2. Former CIAT trainees from Latin America distributed by type of training.

Type of training	N	%
Production and extension	201	16.0
Research support	116	9.2
Research	942	74.8
TOTAL	1259	100.0

* This does not include postdoctoral fellows, nor other students whose training was financially suoported by CIAT but carried out at other educational organizations.

Table D-3. Number of research trainees from Latin America, distributed by country and year of training completion.

Country	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	TOTAL
Antigua	0	0	0	0	0	0	0	0	0	0	1	1
Argentina	0	1	0	0	0	0	0	0	1	3	5	10
Belize	0	0	0	0	0	0	0	0	0	3	3	6
Bolivia	0	0	0	1	0	1	2	3	7	6	7	27
Brasil	0	1	0	26	3	21	7	17	14	46	50	185
Colombia	0	14	5	9	9	14	9	18	13	24	32	147
Costa Rica	1	0	0	3	0	0	1	0	2	8	12	27
Cuba	0	0	0	0	0	0	0	0	0	7	14	21
Chile	0	0	0	0	0	0	7	2	1	5	1	16
Ecuador	0	2	4	5	2	9	1	1	5	10	13	52
El Salvador	0	0	0	0	0	3	4	2	3	2	5	19
Guatemala	0	0	0	0	1	3	4	3	15	4	6	36
Guayana	0	0	0	0	0	2	0	1	1	2	1	7
Haiti	0	0	0	0	0	0	0	0	0	0	5	5
Honduras	0	0	1	1	3	0	1	7	8	8	6	35
Jamaica	0	0	0	1	0	0	0	0	0	0	0	1
Mexico	0	0	0	0	3	0	6	12	5	8	13	47
Nicaragua	0	0	0	0	0	0	0	0	1	4	2	7
Panama	0	0	0	1	0	0	0	3	2	5	2	13
Paraguay	0	0	0	0	1	0	2	1	0	0	0	4
Peru	0	1	0	0	1	2	1	8	6	13	12	44
Puerto Rico	0	0	0	0	0	0	0	1	0	0	0	1
Republica Dominicana	0	2	0	1	0	2	1	4	5	4	14	33
Trinidad	0	0	0	0	0	0	0	0	0	1	0	1
Uruguay	0	0	0	0	0	0	1	0	0	0	1	2
Venezuela	0	0	1	1	0	4	4	8	2	8	8	36
TOTAL	1	21	11	49	23	61	51	91	91	171	213	783

APPENDIX D

General data about CIAT training program.

Table D-1. Total number of former CIAT trainees distributed by geographical regions of the world. *

Region	N	%
Africa, Asia and Australia	65	4.6
North America and Europe	89	6.3
Latin America	1259	89.1
TOTAL	1413	100.0

Table D-2. Former CIAT trainees from Latin America distributed by type of training.

Type of training	N	%
Production and extension	201	16.0
Research support	116	9.2
Research	942	74.8
TOTAL	1259	100.0

* This does not include postdoctoral fellows, nor other students whose training was financially suoported by CIAT but carried out at other educational organizations.

Table D-3. Number of research trainees from Latin America, distributed by country and year of training completion.

Country	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	TOTAL
Antigua	0	0	0	0	0	0	0	0	0	0	1	1
Argentina	0	1	0	0	0	0	0	0	1	3	5	10
Belize	0	0	0	0	0	0	0	0	0	3	3	6
Bolivia	0	0	0	1	0	1	2	3	7	6	7	27
Brasil	0	1	0	26	3	21	7	17	14	46	50	185
Colombia	0	14	5	9	9	14	9	18	13	24	32	147
Costa Rica	1	0	0	3	0	0	1	0	2	8	12	27
Cuba	0	0	0	0	0	0	0	0	0	7	14	21
Chile	0	0	0	0	0	0	7	2	1	5	1	16
Ecuador	0	2	4	5	2	9	1	1	5	10	13	52
El Salvador	0	0	0	0	0	3	4	2	3	2	5	19
Guatemala	0	0	0	0	1	3	4	3	15	4	6	36
Guayana	0	0	0	0	0	2	0	1	1	2	1	7
Haiti	0	0	0	0	0	0	0	0	0	0	5	5
Honduras	0	0	1	1	3	0	1	7	8	8	6	35
Jamaica	0	0	0	1	0	0	0	0	0	0	0	1
Mexico	0	0	0	0	3	0	6	12	5	8	13	47
Nicaragua	0	0	0	0	0	0	0	0	1	4	2	7
Panama	0	0	0	1	0	0	0	3	2	5	2	13
Paraguay	0	0	0	0	1	0	2	1	0	0	0	4
Peru	0	1	0	0	1	2	1	8	6	13	12	44
Puerto Rico	0	0	0	0	0	0	0	1	0	0	0	1
Republica Dominicana	0	2	0	1	0	2	1	4	5	4	14	33
Trinidad	0	0	0	0	0	0	0	0	0	1	0	1
Uruguay	0	0	0	0	0	0	1	0	0	0	1	2
Venezuela	0	0	1	1	0	4	4	8	2	8	8	36
TOTAL	1	21	11	49	23	61	51	91	91	171	213	783

APPENDIX E

Additional tables on the formation of human resource inventories for agricultural research in Latin America and the Caribbean countries.

Table E-2. Number of former CIAT research trainees from Latin America who stayed working in their training fields up to a given number of years, distributed by year of training completion.

Training year	Completed training	Number of years working in fields of training												Data for a total of	Don't know about
		11	10	9	8	7	6	5	4	3	2	1	0		
1969	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
1970	21	0	2	1	0	0	1	1	0	0	0	1	7	13	8
1971	11	0	0	5	0	2	0	0	0	0	0	1	2	10	1
1972	49	0	0	0	10	3	0	0	1	1	0	1	15	31	18
1973	23	0	0	0	0	4	2	2	2	0	2	0	7	19	4
1974	61	0	0	0	0	0	9	7	4	2	2	0	19	43	18
1975	51	0	0	0	0	0	0	6	5	2	4	4	13	34	17
1976	91	0	0	0	0	0	0	0	22	5	5	2	30	64	27
1977	91	0	0	0	0	0	0	0	0	33	7	6	20	66	25
1978	171	0	0	0	0	0	0	0	0	0	90	10	29	129	42
1979	213	0	0	0	0	0	0	0	0	0	0	129	41	170	43
TOTAL	783	1	2	6	10	9	12	16	34	43	110	154	183	580	203

Table E-5. Inventory formation for the period 1969-79, showing initial inventories, trained personnel, non-returnees, drop-outs, and final inventories (n = 580).

	1969	70	71	72	73	74	75	76	77	78	79
For sponsor organization											
Initial inventory	0	1	12	20	49	61	101	123	172	218	308
Trained personnel	1	13	10	31	19	43	34	64	66	129	170
Non-returnees	0	2	1	2	4	1	5	7	5	10	12
Drop-outs	0	0	1	0	3	2	7	8	15	29	37
Final inventory	1	12	20	49	61	101	123	172	218	308	429
For field of training											
Initial inventory	0	1	7	14	29	40	64	81	107	143	222
Trained personnel	1	13	10	31	19	43	34	64	66	129	170
Non-returnees	0	7	2	15	7	19	13	30	20	29	41
Drop-outs	0	0	1	1	1	0	4	8	10	21	40
Final inventory	1	7	14	29	40	64	81	107	143	222	311
For CIAT commodities (together)											
Initial inventory	0	1	7	14	32	44	69	88	115	158	235
Trained personnel	1	13	10	31	19	43	34	64	66	129	170
Non-returnees	0	7	2	12	6	18	12	29	15	26	34
Drop-outs	0	0	1	1	1	0	3	8	8	26	42
Final inventory	1	7	14	32	44	69	88	115	158	235	329
For agricultural research in general											
Initial inventory	0	1	14	22	51	66	108	133	185	241	341
Trained personnel	1	13	10	31	19	43	34	64	66	129	170
Non-returnees	0	0	0	1	1	1	4	5	3	8	4
Drop-outs	0	0	2	1	3	0	5	7	7	21	37
Final inventory	1	14	22	51	66	108	133	185	241	341	470

Table E-6. Cumulative trained personnel, final inventories, cumulative migration, cumulative number of drop-outs, and cumulative number of non-returnees (n = 580).

Perspective	1969	70	71	72	73	74	75	76	77	78	79
Sponsor organizations											
Cum. trained personnel	1	14	24	55	74	117	151	215	281	410	580
Final inventories	1	12	20	49	61	101	123	172	218	308	429
Cumulative migration	0	2	4	6	13	16	28	43	63	102	151
Cumulative drop-out	0	0	1	1	4	6	13	21	36	65	102
Cumulative non-return	0	2	3	5	9	10	15	22	27	37	49
Fields of training											
Cum. trained personnel	1	14	24	55	74	117	151	215	281	410	580
Final inventories	1	7	14	29	40	64	81	107	143	222	311
Cumulative migration	0	7	10	26	34	53	70	114	138	183	269
Cumulative drop-out	0	0	1	2	3	3	7	15	25	46	86
Cumulative non-return	0	7	9	24	31	50	63	99	113	142	183
CIAT commodities											
Cum. trained personnel	1	14	24	55	74	117	151	215	281	410	580
Final inventories	1	7	14	32	44	69	88	115	158	235	329
Cumulative migration	0	7	10	23	30	48	63	100	123	175	251
Cumulative drop-out	0	0	1	2	3	3	6	14	22	48	90
Cumulative non-return	0	7	9	21	27	45	57	86	101	127	161
Research in general											
Cum. trained personnel	1	14	24	55	74	117	151	215	281	410	580
Final inventories	1	14	22	51	66	108	133	185	241	341	470
Cumulative migration	0	0	2	4	8	9	18	30	40	69	110
Cumulative drop-out	0	0	2	3	6	6	11	18	25	46	83
Cumulative non-return	0	0	0	1	2	3	7	12	15	23	27

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