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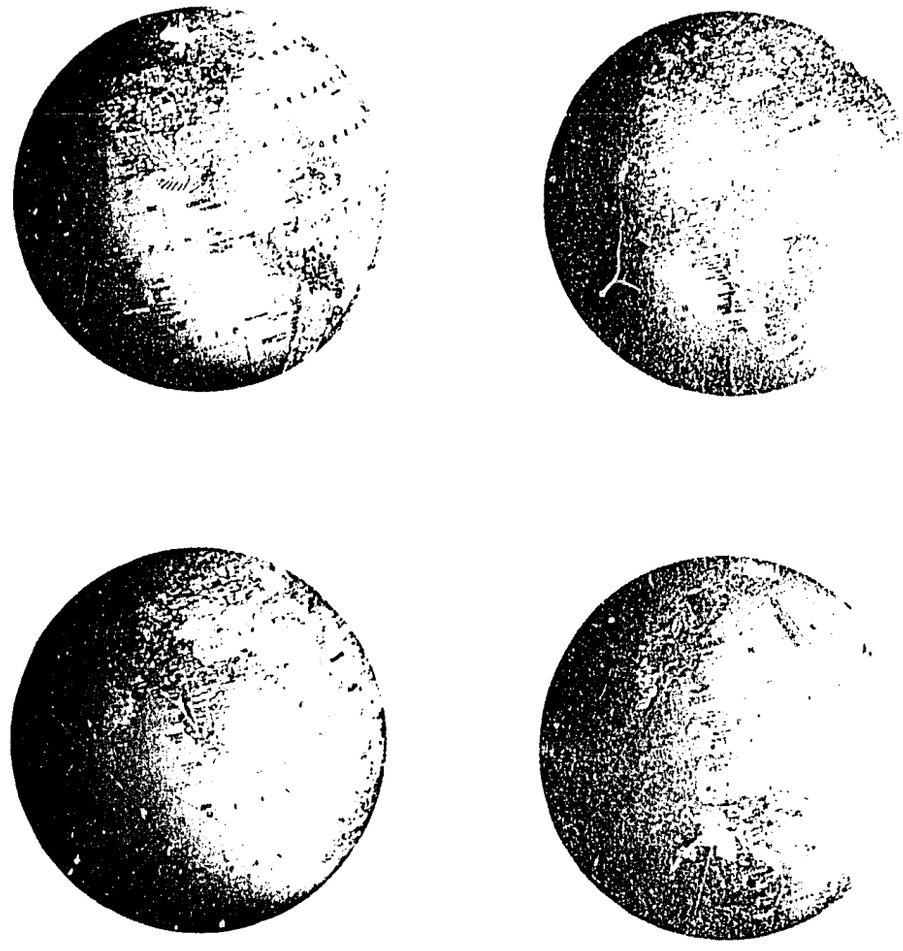

THE EFFECTS OF MODERN TECHNOLOGY ON LABOR NEEDED FOR PRODUCING CROPS ON SMALL FARMS IN TWO INTEGRATED RURAL DEVELOPMENT DISTRICTS IN COLOMBIA

by

Sergio Sepulveda Silva
and
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New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York

May 1979

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INTRODUCTION

There presently exists an almost unanimous consensus among economists, as well as politicians, about the imperative need to attain balanced economic growth among the different sectors of the economies of less-developed nations.[1/] This view is particularly strong in less-developed countries in which dual economic growth and its inherent socio-economic inequities have been the rule rather than the exception throughout their histories. The need to remove the agricultural bottleneck in order to achieve the economic "take off" has been recognized as a sine qua non element for economic development for over two decades.[2/]

The agricultural sector in the majority of Latin American countries continues to be characterized by low productivity. This is reflected in the very low supply elasticity for food which occurs in most developing nations. Moreover, the agricultural sector's low productivity is also responsible for the distinctive rural poverty which is found in most of these countries.

This already critical situation of low productivity in the primary sector is complicated by a high population growth rate. It has been estimated that by the year 2000 the population in the nations of South America will double, reaching 400 million.[3/] This high growth rate is accompanied by one of the fastest growing rates of urbanization in the world. This compounded phenomenon places a heavy burden on already low agricultural production.[4/] Furthermore, population growth contributes to the large army of unemployed and underemployed people already plaguing the rural sector. From the macro-economic point of view, the inelasticity

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1/ Gerald M. Meier, Leading Issues in Economic Development (Oxford: Oxford University Press, 1970), p. 391 and J. Marcus Fleming, "External Economies and the Doctrine of Balanced Growth" in the Economics of Underdevelopment, edited by A. N. Agarwala and S. P. Singh (Oxford: Oxford University Press, 1969), pp. 272-308.

2/ Jerome Levinson and Juan de Onis, The Alliance that Lost Its Way (Chicago: Chicago Quadrangle Books, 1970), pp. 22-23.

3/ Montague Yudelman, El Desarrollo Agricola en America Latina (Mexico, D. F.: BID. CEMLA, 1967) p. 7.

4/ R. d'A. Shaw, "Strategies for Employment Creation in Agriculture," in Karl Wohlmuth Employment Creation in Developing Societies, (New York: Praeger Publishers, 1973) pp. 156-183.

of the food supply has also contributed to inflationary pressures in the majority of Latin American nations. Over the last two decades the price of food increased more rapidly than the price of any other item in the cost of living index in Latin America.[1/] To satisfy the needs of an ever-increasing population it is evident that a special strategy should be pursued in order to achieve higher productivity within the agricultural sectors in these nations.

Moreover, the process of economic growth necessitates the creation of sources of employment within the traditional sector. New jobs will help alleviate the acute rates of unemployment and underemployment observed in these societies.[2/] Lower rates of unemployment will aid in remedying the chronic degree of poverty endured by the rural population. In addition, the absorption of some of the unemployed labor within the rural sector could decrease the strong rural-urban migratory flow.

The solution to this complex problem has been a source of heated controversy in political and intellectual circles for the last two decades. There presently are at least two well-defined positions regarding this complicated issue. At one end of the spectrum are found the "structuralists"; well-known personalities such as Raul Prebish, Edmundo Flores, Solon Barraclough, and William Thiesenhusen, who regard the low productivity, unemployment and uneven income distribution in the rural sector as basically structural problems. They propose institutional changes, e.g., agrarian reform, as a necessary prerequisite to any type of successful technical solution. The structuralists admit the importance of technological change within the context of the traditional sector. However, the solution of the problems, they believe, will be decided by preceding structural changes.[3/]

At the other end of the spectrum are those who propose technological change as the solution. Increases in production, for them, require only

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1/ Montague Yudelman, El Desarrollo Agricola en America Latina, (Mexico, D. F.: BID. CEMLA, 1967), p. 8.

2/ Some authors (P. N. Rosenstein-Rodan and W. A. Lewis) have estimated figures of up to 25 percent of the rural labor force with or close to zero marginal productivity. See Theodore W. Schultz, Transforming Traditional Agriculture, (New Haven, Conn.: Yale University Press, 1969), p. 54.

3/ Uma Lele observations on the role of institutions in Africa: The Design of Rural Development. Lessons from Africa. A World Bank Research Publication (London, The Johns Hopkins University Press, 1975).

the adoption of modern inputs, e.g., fertilizer, improved seeds, etc. Institutional change is not necessary, they believe. This position is a result of the initially successful experiences of the "green revolution" in Mexico, India, Pakistan, the Philippines, and Ceylon.[1/] The position advocated by this group reflects an attempt to maximize the social welfare functions of the rural masses, subject to some of the rigid institutional constraints characterizing less-developed nations.

The success stories of the Mexican and Philippine experiences with the "green revolution" soon gained enough force and momentum to spread the good news of the plentiful harvests of different grains over Asia and Latin America. By 1960, many countries were aiming at self-sufficiency in those grains in which they had been suffering severe shortages only a few years earlier.[2/] During the 1960s there seemed to be little doubt that most countries facing food production shortages could, with the adoption of the proper technological package, become self-sufficient in their basic staple crop.[3/] The remarkable increases in the production of food grains, such as wheat, corn, rice, and sorghum experienced in Mexico, India, and Pakistan during the sixties, seemed to indicate that an epoch of self-sufficiency soon would be achieved by most countries on the globe.[4/] By 1960, through the achievements of the "green revolution," the problem of food supply appeared to have been substantially curbed, and by the mid-1960s most of the fears of a Malthusian famine had been allayed.[5/] Yet, recently there is a feeling that:

1/ Lester B. Pearson, Partners in Development (New York, New York: Praegers Publishers, 1970), pp. 34-35.

The term "green revolution" refers to the new "genetic-chemical" technology based on a sophisticated type of plant breeding and genetic selection, combined with the intense use of petro-chemicals for fertilizing the soil and for controlling pests and weeds, This genetic-chemical technology will be referred to as "new inputs" or "modern inputs" throughout this study. The diffusion of the modern inputs first took place in Mexico in the late 1940s and during the early 1960s in the Philippines. See Lester R. Brown, Seeds of Change (New York: Praeger, 1970), p. 3.

2/ E. J. Wellhausen, "The Urgency of Accelerating Production on Small Farms," Strategies for Increasing Agricultural Production on Small Holdings, edited by Delbert T. Myren (Puebla, Mexico: International Conference, August 1970), p. 6.

3/ Schultz, op. cit., p. 103.

4/ Lester Brown, op. cit., p. 379.

5/ Lester Brown, "United Nations World Population Conference," New York Times, (August 21, 1974).

"The new seeds do not provide an ultimate solution to the food-population problem. The collision between population growth and food production has been averted only temporarily."1/

Environmental conditions as well as limitations inherent to high yielding varieties, (HYV) have been shown to have had a critical limiting role on production increases of some crops which were attained through the use of modern inputs. These unexpected constraints have made the scientists a bit more realistic about the possible reach of the green revolution.

As Keith Griffin views it,

"Although the impact of the green revolution on total agricultural production has been relatively slight, the introduction of high yielding varieties has led to an increase in domestic supplies of some foodstuffs in several countries."2/

However, much was left to be desired in relation to the attainment of the social objectives of the "green revolution." By 1975, it was evident that the economic gains achieved through the use of modern inputs had not filtered down to the majority of peasants. In fact, the economic gap between the rich and the poor peasants had widened as a result of the adoption of "modern inputs." The adoption of the new technology was largely limited to the well-to-do farmers, while the vast majority of minifundistas3/ continued to use traditional inputs, consequently reaping no benefit from the technological changes of the green revolution.4/ Rural poverty continued to be pervasive and unemployment persisted almost unchecked. "The explosive widening of regional income disparities was one of the most intractable consequences of the green revolution."5/

1/ Lester Brown, Ibid.

2/ Keith Griffin, Policy Options--The Social and Economic Implications of the Large Scale Introduction of High Yielding Varieties of Food Grain (Geneva, Switz.: UNRISD, September 1972), p. 13.

3/ Small-holders.

4/ M. Schulter found this phenomenon also true for India. See The Interaction of Credit and Uncertainty in Determining Resource Allocation and Incomes on Small Farms, Surat District, India. Occasional Paper No. 68. (Ithaca, New York: Cornell University, Department of Agricultural Economics, February 1974).

5/ Uma Lele and J.W. Mellor, "Jobs, Poverty, and the Green Revolution," International Affairs (January 1972), p. 28.

To speed the process of growth in agricultural production and to redistribute wealth, effective policies are needed to bring the green revolution to the small farmers.

International institutions, as well as their national counterparts in less developed countries, launched their counter-attack late in the 1960s. The basic idea of this rejuvenated approach was to introduce the new technology directly to the small-holders in order to increase their productivity, increase their income and decrease unemployment. Based on these premises, the Puebla Project was founded in Mexico in 1967. This typical example of the "new approach" of the "green revolution" was a joint venture between the Mexican government and the Rockefeller Foundation.[1/]

Other Latin American nations, e.g., Brazil, Paraguay, Ecuador, and Colombia, have tried to pattern some programs after the Puebla Project. One of the most successful efforts has been the Regional Rural Development Projects[2/] in Colombia which were the basis for the Integrated Rural Development Plan launched by the Colombian Government in 1975. Instituto Colombiano Agropecuario (ICA) was the institution charged with the operation of the Rural Development Projects (RDP) in Colombia.

The RDP's program was patterned after the Puebla Project with adaptations to the realities of the Colombian small scale farmer, e.g., associated cropping and a wide variety of crops. Moreover, ICA wished to complement Puebla's productivity orientation with a social welfare dimension. ICA's conception of rural development went beyond the traditional frame of higher productivity by including the goals of increased and better distributed incomes and improved living conditions. It was postulated by ICA that given the small-scale farmers' factor endowments the only way to achieve income growth was to utilize a broad integrated approach to rural development in which credit (capital) and new technology would play a crucial role.

1/ Leobardo Jimenez Sanchez, The Puebla Project: A Regional Program for Rapidly Increasing Corn Yields Among 50,000 Small Holders (Puebla, Mexico: International Conference, August 1970), p. 12; and The Puebla Project 1967-69: Progress Report of a Program to Rapidly Increase Corn Yields on Small Holdings (Mexico, D.F.: CIMMYT, 1970).

2/ Canuto A. Cardona, et al., Los Proyectos de Desarrolo Rural Regional Informacion General, Documento No. 2 (ICA: Bogota, Colombia, 1971).

ICA's experience in the rural sector permitted it to formulate the objectives of RDP as follows: (i) Increasing productivity among small-scale farmers through an efficient use of factors of production; (ii) Increasing living standards and social welfare of the peasants through increases in employment opportunities, income and infrastructural services; (iii) Encouraging and facilitating the peasants' participation in existing associations and in the creation of new ones; (iv) Coordinating institutions from the private and public sector to generate an efficient program to encourage the development of depressed areas.

This new approach to rural development was put into action in the eastern regions of Cundinamarca and Antioquia Departments[1/] by the end of 1970. The two regions chosen to operationalize the Integrated Rural Development Program contain predominantly minifundios with low incomes. The project's target clientele included farmers with less than 10 cultivable hectares.

The first two programs, Caqueza (Eastern Cundinamarca) and Rionegro (Eastern Antioquia) were seen by ICA as pilot projects from which to gain sufficient experience to expand the RDP program to the rest of the country. It was a living experiment in rural development designed to generate the base for a national Integrated Rural Development Program.

This study is an appraisal of selected aspects of the results achieved by these projects. Moreover, it is hoped that the analysis presented in this study will serve as the base for further improving these projects.

OBJECTIVES OF THE STUDY

The overall objective of this study is to ascertain the impact that new technological packages have had upon the demand for and composition of the labor force on minifundios, in two Integrated Rural Development Districts in Colombia.

Specific objectives relate to the testing of the following hypotheses: (i) The use of new technologies has induced a higher total use of labor. (ii) The use of these packages has induced a greater increase

---

1/ In the Colombian political-administrative division the Department is equivalent of a State and the Vereda corresponds to the County.

in the use of hired labor than family labor. (iii) The use of new technologies has increased the demand for labor at peak periods, leading to labor bottlenecks. (iv) The use of fertilizers, pesticides and fungicides induces a greater labor demand than does the adoption of new seeds, and/or higher plant densities per hectar. (v) The composition of the labor force, in terms of family, hired and exchanged, has changed with the new technology.

SAMPLE CHARACTERISTICS

Insufficiently detailed base line information precluded this research from comparing the farming operations of a given group of minifundistas before and after their adoption of new technology. Instead samples of two subgroups of small farmers were chosen, one consisting of farmers who had adopted new technology and the other of farmers who had not. This analytical approach assumes that the general characteristics of the farms of adopter minifundistas prior to adoption closely resembled those of the farms now operated by non-adopters.

Although these groups actually do appear to present resemblances at the farm level they seem to differ in their proximity to some infrastructural services, especially roads and any services, such as extension education, related to roads. This observation is valid for both districts studied.

Input as well as output cross-sectional data on the two most frequent associated crops, maize-beans and potato-peas, were collected between February and May 1976 in the two aforementioned districts.[1/]

Only farmers who grew maize-beans or potato-peas were sampled. These are the most important crops in the two project areas and are the ones for which new technology has been most vigorously promoted.

Most of the information collected also was confined to these crops. It would have been useful to have information on the total farming operations of those growing these crops but this was beyond the resources of this project. Farmers, instead, were asked only to estimate their inputs and outputs, and to describe their general practices and timing of operations, for maize-beans and potato-peas.

1/ The most important crops in the two project areas are normally grown in associations, maize with beans and potatoes with peas.

Maize-bean and potato-pea farmers were stratified on the basis of their degree of technological adoption and random samples were chosen within strata.

Three strata were identified for the two associated crops in each District.

(i) The first stratum was the minifundistas who received technical assistance from ICA and credit from Caja Agraria. They are the group with the most advanced technology adoption.

(ii) The second subgroup was the farmers who receive only credit from Caja Agraria without complementary technical services. The degree of modern input adoption observed in this group is lower then the technical recommendations specified by ICA. This subgroup was the intermediate technology adoption stratum. It was found, however, that this group in case of maize was very similar to the non-adopters, while in the case of potatoes it was much like the adopter group. Members of the sample selected from this stratum were combined in the analyses with the respective groups to which they were similar.

(iii) Finally, the stratum with almost no technology adoption consisted of a list generated in conjunction with the ICA and Caja Agraria employees who knew most of the farmers throughout their respective project areas. The common characteristics of these individuals was both lack of technical aid from ICA and no source of credit which would allow them to use "modern" technology.

The information presented in this report is based on the study of 153 maize-bean enterprises and 140 potato-pea enterprises. These are divided between the two levels of technology and the two districts as follows:

	Maize-Beans		Totals
	Modern (T_1)	Traditional (T_0)	
Caqueza	30	44	74
Rionegro	39	40	79
Totals	69	84	153
	Potato-Peas		
Caqueza	28	34	62
Rionegro	38	40	78
Totals	66	74	140

The information collected on each enterprise included:

(i) Land resources available: Owned and rented land and the per-hectare value of rent; total number of hectares cropped; and tenure conditions. Moreover this information includes some soils characteristics, e.g., percent of organic matter; depth of the A horizon; slope; erosion; and type of drainage.

(ii) Labor; human and animal labor; labor classified by source; figures on family, hired and exchanged labor by phases of the production process.

(iii) Capital.

(a) Current inputs: quantity of cash resources invested in seeds, fertilizers, pesticides, fungicides and bullock or tractor power.

(b) Fixed capital: tools used in the production process. Usually these are very simple implements consisting of wooden plows, pick-axe, machete, shovel, fumigation pump, lever, etc.

(iv) Production figures and the value of the crops were also recorded.

RESOURCE ENDOWMENTS OF THE TWO DISTRICTS STUDIED

This part depicts the most salient topographic, climatic and social characteristics of the environment within the two districts. Differences

in climate, associated mostly with differences in altitude are especially critical constraints on the type of products the peasant can produce.

The Caqueza District: Geographical and Climatic Characteristics

The Caqueza District is located in the southeastern region of the Cundinamarca Department,[1/] 45 kilometers or 1-1/2 hours from Bogota, Colombia's capital city (Map No. 1 and 2). This district is served by the paved road that joins Bogota to Villavicencio. Caqueza District covers 227,000 hectares which are divided into nine municipalities (Table 1). Each of these municipalities is subdivided into veredas. As can be observed in Table 1 the variations in elevation are very pronounced, ranging from about fifteen hundred meters to as high as 2,400 meters. These generalized figures mask the fact that the full range of altitude is greater yet. It is common to observe elevations of less than 1,000 meters up to as high as 3,900 meters.

These changes in altitude generate quite different microclimates which determine the productive capacity in each zone. The highest zone, localized above 2,100 meters, (average temperature 13°C) is predominantly dedicated to pastures and potatoes, although some farmers do grow small amounts of maize for family consumption.[2/]

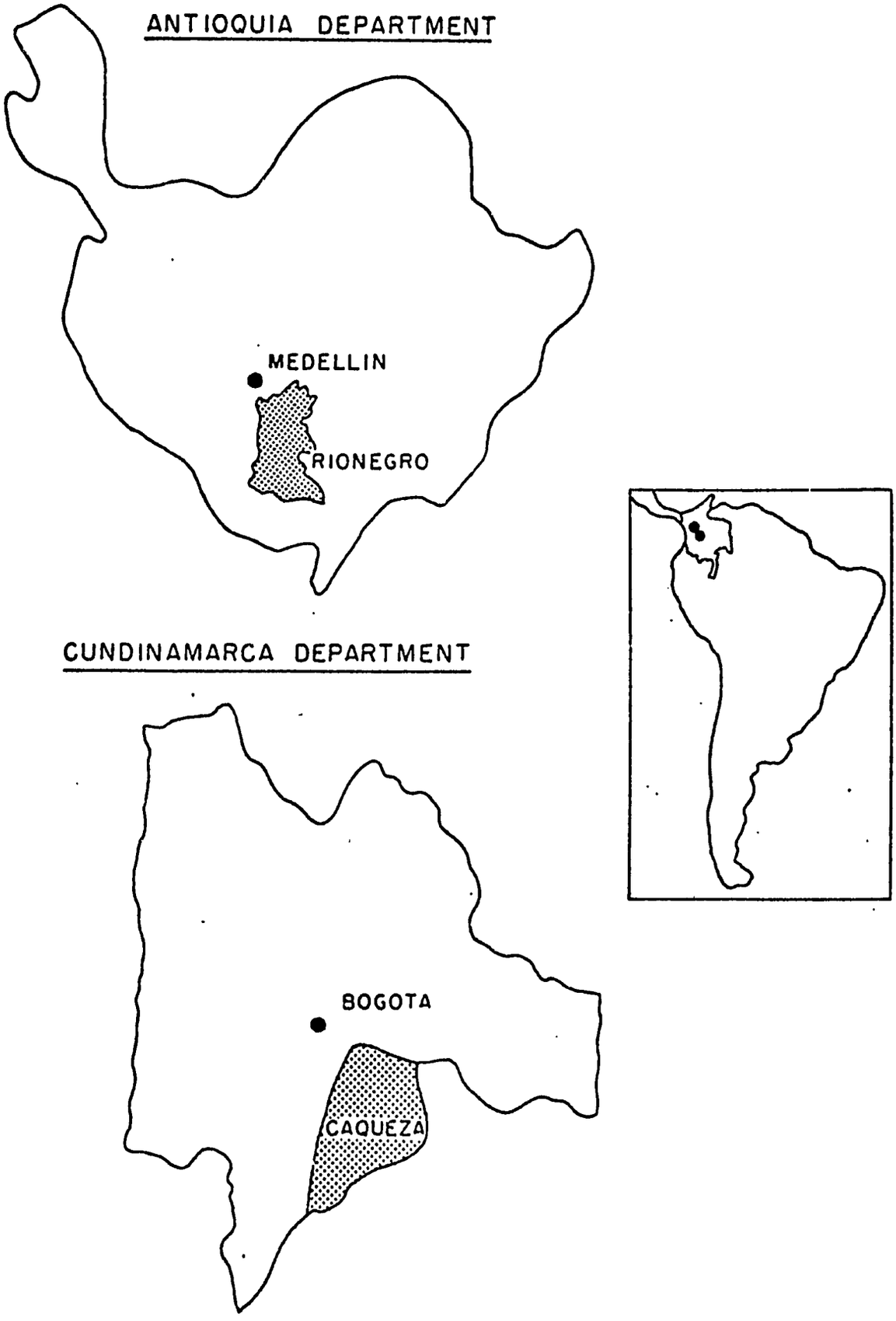
A second agricultural production zone lies between 1,800 and 2,100 meters with average temperatures of 17°C. In this transition zone it is possible to find horticultural crops, while the production of potatoes tends to diminish and at the same time corn production becomes more relevant.

The third production zone is located below 1,800 meters, with average temperatures of 20°C. Agricultural activity in this region is dominated by the production of corn in association with beans. Associated with these elevation differences are differences in water availability; there is a direct relationship between altitude and water available to crops.

1/ In the Colombian political-administrative division the Department is the equivalent of a State and the Vereda corresponds to the County.

2/ The corn grown at this altitude takes up to eleven months in its vegetative period instead of the 8 to 9 months in lower regions.

MAP 1. GEOGRAPHIC LOCATION OF CAQUEZA AND RIONEGRO DISTRICTS



MAP 2. CUNDINAMARCA DEPARTMENT AND CAQUEZA DISTRICT (With insert showing position within Colombia

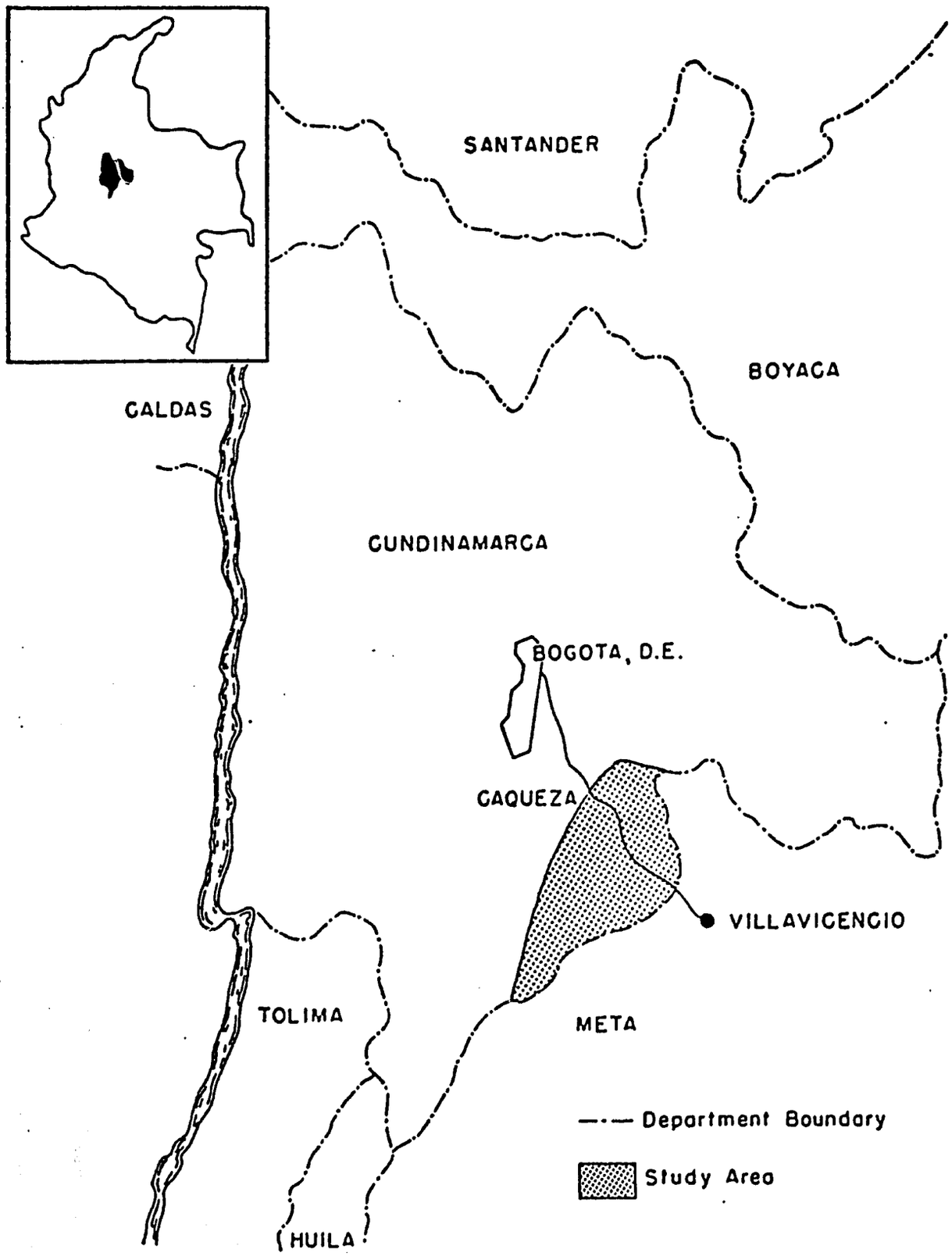


TABLE 1

MUNICIPALITIES AND GENERAL CHARACTERISTICS OF CAQUEZA DISTRICT

Municipality	Area (ha.)	Altitude (meters)	Temperature °C	Urban Population	Rural Population	Total People per sq.km.
Caqueza	10,700	1,876	19	3,735	10,545	133
Chipaque	12,400	2,400	16	2,028	6,114	65
Choachi	21,500	1,927	18	2,635	8,164	50
Fomeque	48,100	1,825	18	2,842	8,072	22
Fosca	12,300	2,113	17	1,008	5,985	56
Gutierrez	52,200	2,350	16	993	3,650	8
Quetame	41,600	1,496	20	1,059	7,892	22
Ubaque	11,600	1,867	18	778	7,277	69
Une	16,800	2,376	16	2,165	4,511	40
TOTAL	227,200	--	--	17,243	62,210	35

German, Escobar, Proyecto de Desarrollo Rural del Oriente de Cundinamarca. Diagnostico Socioeconomico. Regional No. 1, (Bogota, Colombia: ICA, 1973) and German Escobar, Comparative Analyses and Technical Recommendations among Minifundistas' Production Processes in the Rural Development Project of Eastern Cundinamarca, Colombia. Unpublished M.S. thesis, Cornell University, Ithaca, New York, 1975.

This region, in general, presents a typical tropical rainfall pattern, i.e. a rainy season followed by a dry period. The rainy season usually starts by the middle of March, reaching its peak by the end of June or beginning of July. This wet season is followed by a short dry period which ends by the middle of September when a new short rainy season begins for about a month. The driest period of the year starts about the middle of November and lasts through the middle of March.

The two factors just mentioned, altitude and rainfall are the most critical environmental constraints, limiting production activities to only one harvest per year in contrast with lower lands which if they possess irrigation facilities can produce two harvests a year.

Socioeconomic Characteristics of Caqueza District

The high population density characterizing this area was a crucial factor in the Colombian Government's decision to select Caqueza as a District within which to implement the Integrated Rural Development Plan. This area is a typical minifundio region. The majority of the farms, nearly 65%, are less than 5.0 hectares in size and cover only 28.5 percent of the total area. Only 20% of all the farm units are between 5.0 and 11.0 hectares. On the other hand, 13 percent of the farms, operate over 60% of the total land available. However, most of the land on these larger farms is upland, mountain grazing, and forest which are not very suitable for cultivation.

The large majority (80%) of the small farms are owned by their operators. The most frequent use of land in this area is to produce the corn-bean and the potatoes-peas crop associations; these associations use nearly 80% of the land under cultivation. Crop activities constituted the larger component of the agricultural output. Almost all farms do have a few cattle, a poultry flock and one or two pigs. In general, it can be said that on the average, animal production activities are below commercial size.

The Rionegro District: Geographical and Climatic Characteristics

Rionegro District is located in the eastern part of the Antioquia Department; it is approximately 45 kilometers from Medellin, the capital city of that department. This District is connected by several good

paved roads to Medellin and other large towns (Map 3). Rionegro District covers 16,700 hectares which are divided into 8 Municipalities (Table 2).

The fluctuations in altitude are less drastic in this region than in Caqueza, with the average altitude ranging from 1,900 to 2,300 meters above sea level. Although the altitude range is smaller, altitude divides the environment into three distinct climatic zones and consequently into the same number of production zones. Bernal[1/] estimated that 84.8 percent of the total surface could be classified as a cold zone; 14.2 percent as a temperate zone; 0.2 percent as hot; and 0.8 percent as Paramo, or extremely cold.

The cold zone is characterized by the predominance of pastures and potatoes (the crop association potato-peas). Some minifundistas do plant small amounts of other crops here such as corn and beans, but this is done only for family consumption. The temperate zone is predominantly dedicated to maize associated with beans.

These production zones are free from the dangers of frost. This climatic factor has been decisive in some years, by practically eliminating potato production in the Bogota and Tuquerres plateaus.

The rainfall pattern observed in this District is typical for the equatorial zone; that is, rainy periods followed by dry seasons. The average rainfall for this District is 1,900 millimeters per year. The months with highest recorded precipitation are May and October; while the periods December-March and June-August show scarce rainfall.

These two climatic factors, temperature and rainfall, constrain corn production activities to only one harvest a year. However, they permit cultivation of potatoes almost all year round. It often is possible to observe plots of potatoes at several different stages of their vegetative period within a given farm.

Socioeconomic Characteristics of Rionegro District

This District represents a typical minifundio area, where the salient problems are: (a) High population density; (b) Land subdivided into small plots; (c) Low net incomes resulting from low land productivity; (d) High unemployment and underemployment rates.

1/ F. Bernal, R. M. Mercado and H. Lopera. "Estudio Socioeconomico del Oriente Antioqueno." (Regional No. 1, Instituto Colombiano Agropecuario, Bogota, Colombia, 1972).

MAP 3. ANTIOQUIA DEPARTMENT AND RIONEGRO DISTRICT (With insert showing position within Colombia)

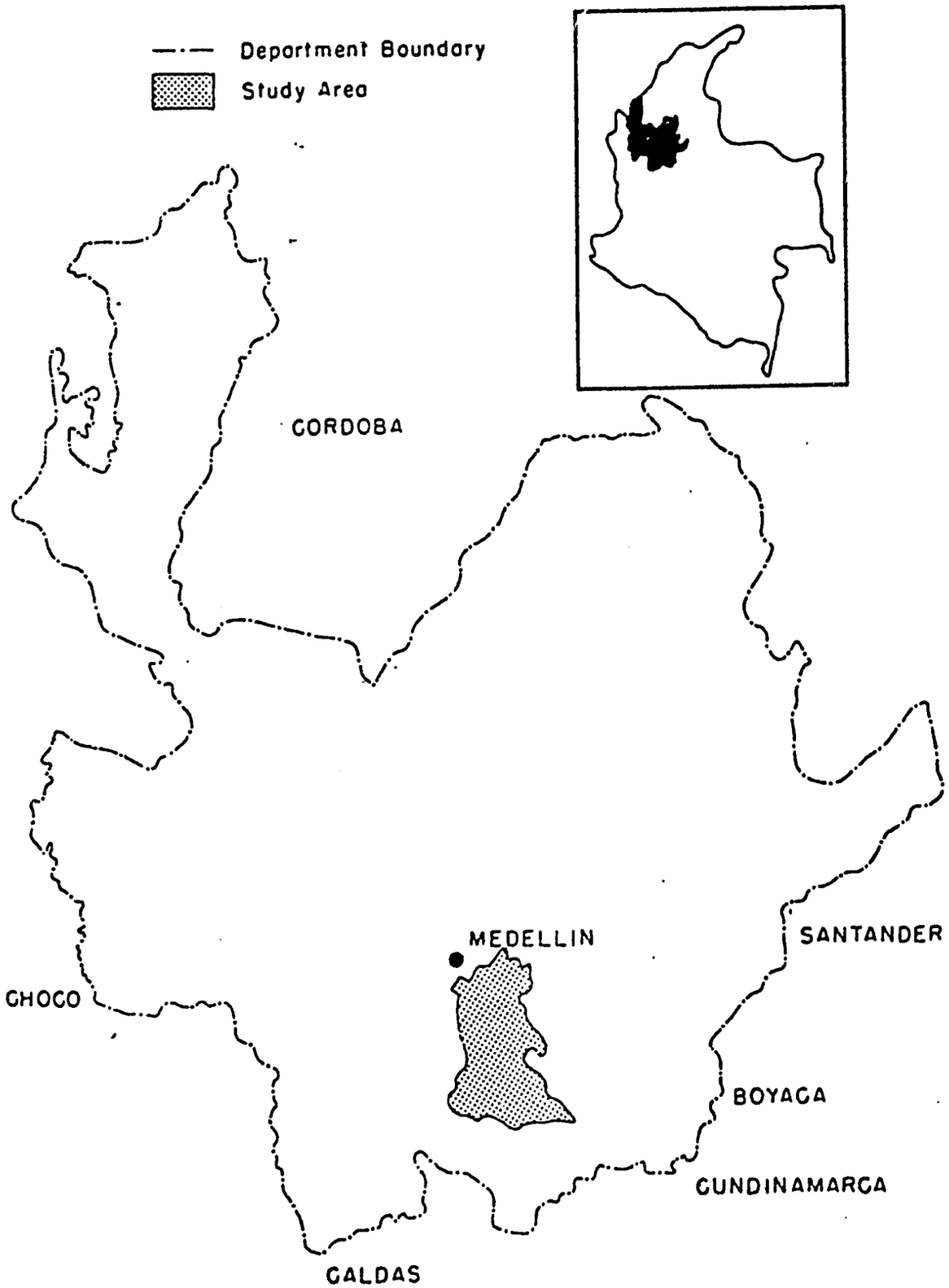


TABLE 2

MUNICIPALITIES AND GENERAL CHARACTERISTICS OF THE RIONEGRO DISTRICT

Municipality	Area (Km.)	Average Temperature (°C)	Total Population
Rionegro	196	18	34,830
Carmen de Viboral	443	17	28,810
La Ceja	159	18	21,520
Santuario	94	17	20,820
Marinilla	115	17	18,850
La Union	256	17	12,680
San Vicente	243	17	15,830
Guarne	165	17	15,300
TOTAL	1,671	--	149,790

Luis A. Rodriguez S. et. al. "Informe al Primer Seminario Internacional de Proyectos de Desarrollo Rural Regional." P.D.R.O.A. (Bogota, Colombia: Instituto Colombiano Agropecuario, ICA, 1972).

Large farms are seldom observed in this District and the few encountered are suitable almost exclusively for cattle grazing.

The large majority of farm units, nearly 95 percent, are owned by their operators. Seldom is leasing observed in this region. Nearly 90 percent of the cultivable land is used for the production of potatoes, maize and beans.[1/] Potatoes produced in La Union Municipality account for nearly 10 percent of the total national potato production. Potatoes are the crop marketed most frequently in this area. The production of maize and beans is almost exclusively for family consumption.

The animal component of the farm is similar to the one observed in Caqueza District -- one or two cows, a poultry flock of 15 to 20 birds and 2 or 3 pigs.

Types of Production Systems in the Two Districts

The two Districts under analysis present a high frequency of associated crops (see Figure 1). Associated crop systems are the norm in most zones of minifundio in South America. For this reason it becomes necessary to specify a refined classification of the different types of cropping by component parts.

The majority of farmers practiced some form of associated cropping with two or more crops planted concurrently.[2/] This overlapping in the use of the land may either result from planting the two crops in the same row or in alternate rows (intercaleted). The associated system permits the simultaneous production of more than one crop in the same agricultural year by increasing the intensity of land use.

Some associated systems of crop production involve successive or overlapping crops planted in the same crop year.[3/] Such arrangements may involve: (i) planting a different crop after one has been harvested; (ii) planting the same crop twice a year on the same plot; and (iii) planting the same or a different crop before the one in the ground has been harvested. These practices are known as relevo or relief of crops.

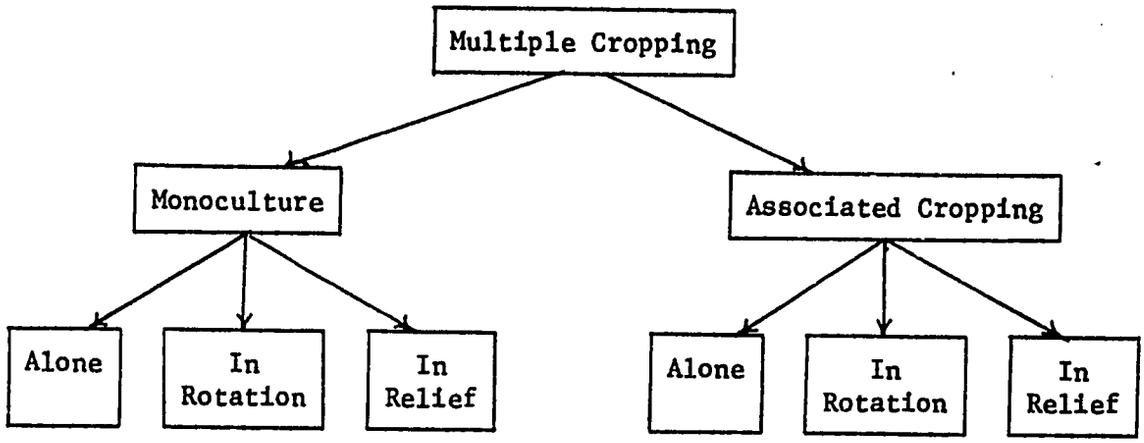
1/ Jose H. Tobon C., "La Investigacion Agricola, Realizaciones y Necesidades en el Area del Proyecto Oriente Antioqueno," (Rionegro, Antioquia, Colombia, Instituto Colombiano Agropecuario. ICA, 1975).

2/ Jose H. Tobon C., op. cit., p. 22.

3/ Hubert Zandstra, et al., "Caqueza Living Rural Development," (International Development Research Centre, Bogota, Colombia. In preparation to be published in 1978).

FIGURE 1

CROPPING SYSTEMS IN THE CAQUEZA AND RIONEGRO DISTRICTS



Two crops are classified as "associated when they are seeded at the same time in a plot and they compete or complement each other during most of their vegetative cycles. The other crop systems involve successive plantings placed in the same field. These are termed relevos."[1/]

The major reasons argued by farmers in defense of the associated crops, have to do with factor scarcity and risk aversion. Tobon[2/] believes that some of the major reasons for associating crops are: (i) More intensive use of land; (ii) Better water utilization; (iii) Better use of fertilizers; (iv) Erosion prevention; (v) Improved control over diseases and insects; (vi) Increased use of family labor; and (vii) Higher net returns due to lower risk of losses by weather or low market prices.

Some of the reasons for crop associations can be summarized by saying that the minifundista is very much aware of the risks involved in his activity. He is trying to minimize risk. Moreover, the scarcest factor of production in these regions is land and this system of production permits a more intensive use of land. Family labor is a "free factor" and this production system demands a higher labor use than does a monoculture.

1/ Jose H. Tobon C., op. cit., p. 123.

2/ Jose H. Tobon C., "Sistemas Tradicionales del Cultivo de Frijol." (Regional No. 4, Instituto Colombiano Agropecuario, Rionegro, Antioquia, 1975), p. 7.

FACTORS DETERMINING THE ANNUAL DISTRIBUTION OF LABOR USE

The seasonality[1/] of the agricultural production process is one of the most striking characteristics differentiating agriculture from its industrial counterparts. This pervasive peculiarity of unirrigated regions in the tropics is mostly determined by an ecological factor, i.e. water availability. The annual rainfall distribution is one of the determining factors of cropping patterns in unirrigated Andean regions in Latin America. Farmers must follow the cyclical rainfall changes and adjust their production activities to this climatic factor.

Although rainy seasons occur with annual regularity, during the year there are great geographic variations in rainfall patterns in Columbia. Since vegetative periods are determined by the rainfall pattern, these, in turn, determine the annual distribution of labor. Thus, the farmer's need for labor at any given time is dependent upon the rainfall and associated cropping patterns.

The introduction of new technologies of bio-chemical or mechanical origin, i.e. high yielding varieties, fertilizers, insecticides, tractors, etc. generates changes in the quantity of labor utilized in the different operations of the production process, as well as in the composition of the labor force. The main objective of this study is to trace the changes in the characteristics of the labor force, both total labor and its components (family, hired and exchange labor), that result from the adoption of new technologies. Employment in this study is measured as man-days per operation for two crop associations, maize-bean and potato-peas. Hence, this analysis will be confined to tracing the direct effects of technological change upon employment.

The first part presents a descriptive analysis of the quantitative and qualitative changes in employment due to technological change. This section will depict: (i) the seasonality of labor needs; (ii) the use

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1/ For an ample treatment on the seasonality of employment in agricultural production see: Yony de Sa Barreto Sampaio and Jose Ferreira Irmao. Emprego e Pobreza Rural. Una Visao Critica da Teoria e Aplicacao ao Caso de Pernambuco. (CME/PIMES) Centro de Cinencias Sociais Aplicadas (Recife: Universidade Federal de Pernambuco, 1977), pp. 95-121.

of total labor; and (iii) the composition of the labor force. This presentation is based on a comparative analysis of two groups of small farmers. The remainder of the paper focuses on a detailed analysis of the effects of new inputs on labor use.

IMPACT OF TECHNOLOGICAL CHANGE UPON THE SEASONALITY OF LABOR NEEDS

Technological change at the farm level might induce a more intensive utilization of laborers. Furthermore, in zones with irrigation facilities these increases could lead to a more even distribution of labor use throughout the year via crop diversification. However, in regions devoid of irrigation the use of "land-augmenting technologies" will more likely lead to more intensive use of laborers per hectare during approximately the same seasonal production patterns defined by the rainfall cycles.

The figures presented in Table 3 for the maize-bean system in Caqueza fit the latter pattern, i.e. the adoption of modern technology does not significantly shift planting dates or even out the annual use of labor. Both groups, the adopters of new technology (T_1) as well as small-farmers using traditional methods of production (T_0), prepare the land immediately after the first heavy rainfall--(end of March and during April). Thus, water availability, not modern technology seems to be the critical factor determining the initiation of the production process.

Promptly after the land preparation takes place, maize and beans are planted; that is March and April are the months in which 90% of the farms studied in Caqueza District plant both maize and beans. The rest of the cropping operations follow the natural vegetative period of maize. As proposed ex ante, the use of fertilizers and/or chemicals does not generate significant changes in the timing of operations. This is particularly true as a result of the chronological overlapping of chemical application with planting and/or weeding operations. Finally, maize harvesting is determined by the planting date and the extra period during which the farmer leaves the kernel on the stalk. Thus, nearly ninety percent of the farms harvest maize in November and December. The similarity of time schedules between the two groups (T_1 and T_0) is shown in Graph 1. This time schedule contains peaks and troughs for both groups that correspond quite closely. Work is concentrated during the months

TABLE 3

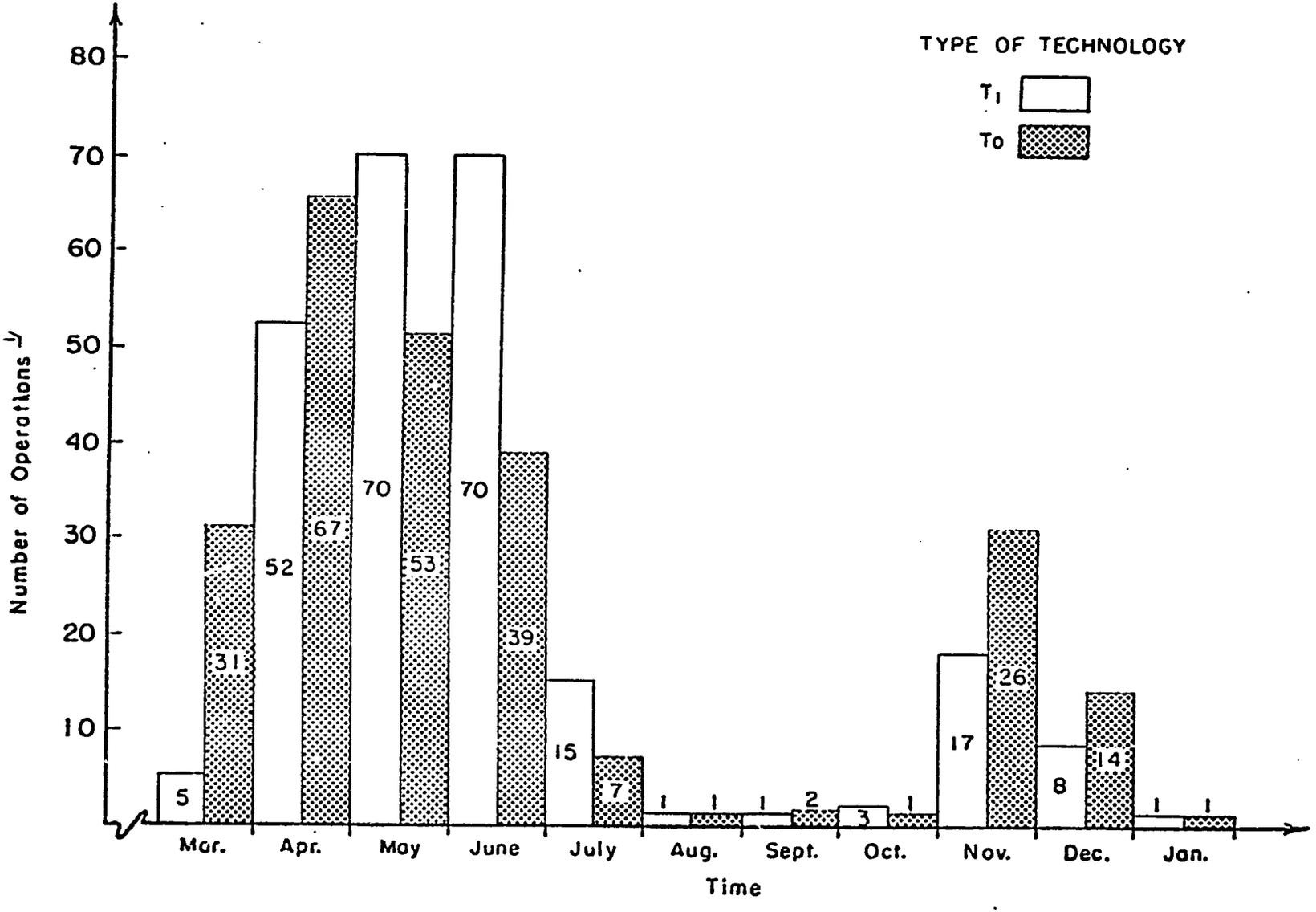
THE TIMING OF PRODUCTION OPERATIONS IN MAIZE-BEANS PRODUCTION IN THE CAQUEZA DISTRICT

Operation	Type of Technology	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
							Number of Operations							
Land Preparation	T_1	0	0	5[a]	22[a]	3[a]	0	0	0	0	0	0	0	0
	T_0	0	0	20[a]	19[a]	5[a]	0	0	0	0	0	0	0	0
Planting	T_1	0	0	0	17[a]	13[a]	0	0	0	0	0	0	0	0
	T_0	0	0	7	28[a]	9[a]	0	0	0	0	0	0	0	0
Weedings	T_1	0	0	0	2	17	29	9	1	0	0	0	0	0
	T_0	0	0	0	9	34	35	7	1	0	0	0	0	0
Fertilizing	T_1	0	0	0	9	22	31	3	0	0	0	0	0	0
	T_0	0	0	4	11	4	4	0	0	0	0	0	0	0
Insecticide Applications	T_1	0	0	0	2	15	10	3	0	0	0	0	0	0
	T_0	0	0	0	0	1	0	0	0	0	0	0	0	0
Harvesting	T_1	0	0	0	0	0	0	0	0	1[a]	3[a]	17[a]	8[a]	1[a]
	T_0	0	0	0	0	0	0	0	0	2[a]	1[a]	26[a]	14[a]	1[a]
Total Number Operations	T_1	0	0	5	52	70	70	15	1	1	3	17	8	1
	T_0	0	0	31	67	53	39	7	1	2	1	26	14	1

[a] In these cases each farmer performed one and only one operation per crop season, so the total number of operations corresponds to the total number of farms (T_1 = 30 farms and T_0 = 44 farms). In the other cases a given farmer may perform none or several operations, ie. he may not apply any insecticide at all or may make several applications.

SOURCE: S. Sepulveda. Impact of Modern Technologies upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH I. SEASONAL DISTRIBUTION OF MAIZE BEANS PRODUCTION OPERATIONS FOR FARMS IN CAQUEZA BY TYPE OF TECHNOLOGY



1/ A completed process of land preparation, a planting, a weeding, a fertilizer application, an insecticide application, and a completed harvesting are each called an "operation." Some operations are always performed once and only once in a crop season. Others may not be performed at all by some farmers or may be performed more than once.

of April, May and June, during which the planting, weeding, insecticide application and fertilizing take place. This peak period is succeeded by a fairly long slack period that lasts through October. Afterwards, there is a five week secondary peak of activities during harvest. This takes place during the last week in November and the month of December.

The time schedule observed for the maize-bean farmers in Rionegro presented an analogous pattern (Table 4). That is, the group of farmers using modern technology (T_1) and those following traditional methods (T_0) observed very similar time schedules.

Although the land preparation in Rionegro occurs over a wider time span than in Caqueza, i.e. from the end of December until the beginning of March; maize planting is reduced to the last week in January, the month of February and the first week in March. However, the time distribution for the maize-bean system in Rionegro differs from the one in Caqueza (Graph 2). The major source of this difference is the distinctive treatment given to beans in both Districts. Contrary to the practice observed in Caqueza, beans in Rionegro are planted about five months after the maize has been planted. Furthermore, it is a common practice to spray the beans in a fashion similar to that used for potatoes. Spraying the beans with a solution of mixed fungicides and insecticides is the norm in this District. Although the model number of applications is four to five per season, this figure can be as high as ten applications per vegetative period. The sprays are performed at fifteen to eighteen day intervals.

The figures in Table 4 indicate that the T_1 and T_0 groups show negligible differences in their operations time schedule. Those operations directly related to new technologies, i.e. fertilizing and sprayings, follow basically similar time patterns for both groups.

The timing operations for the maize-bean system in Rionegro are delineated in Graph 2, and the conclusive picture for these groups is similar to one already depicted for Caqueza. This time frequency distribution clearly generates two periods of peak activity in farm operations. The first peak corresponds to the maize planting operation. This period is succeeded by an interval with a lower number of farming operations corresponding to the months of April, May and June. However, unlike the phenomenon observed in Caqueza, June is not followed by several slack months, due to the later introduction of beans. Hence,

TABLE 4

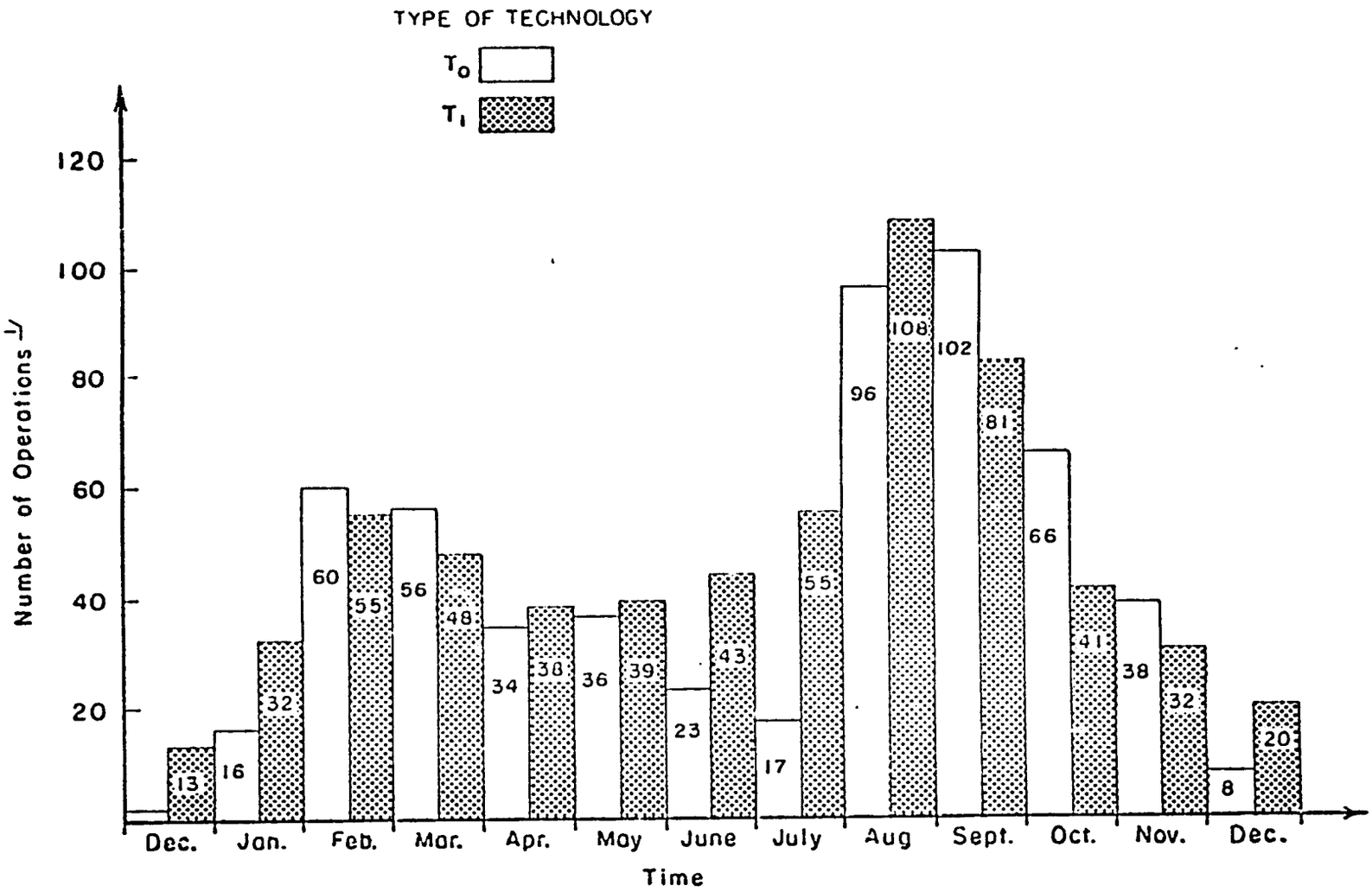
THE TIMING OF PRODUCTION OPERATIONS IN MAIZE-BEANS PRODUCTION IN THE RIONEGRO DISTRICT

Operations	Type of Technology	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
		Number of Operations												
Land Preparation	T_1	10[a]	14[a]	13[a]	2[a]	0	0	0	0	0	0	0	0	0
	T_0	1[a]	12[a]	16[a]	11[a]	0	0	0	0	0	0	0	0	0
Planting	T_1	2[a]	12[a]	14[a]	11[a]	0	0	0	0	0	0	0	0	0
	T_0	0	2[a]	25[a]	13[a]	0	0	0	0	0	0	0	0	0
Weedings	T_1	0	2	13	19	25	21	16	14	19	13	11	4	1
	T_0	0	0	4	22	31	31	19	7	18	10	15	2	0
Fertilizings	T_1	1	4	12	15	12	15	12	17	8	2	2	0	0
	T_0	0	2	15	7	2	5	2	6	8	6	4	0	0
Sprayings	T_1	0	0	3	1	1	3	15	24	81	66	25	11	0
	T_0	0	2	0	3	1	0	2	4	70	86	38	13	0
Harvesting	T_1	0	0	0	0	0	0	0	0	0	0	3[a]	17[a]	19[a]
	T_0	0	0	0	0	0	0	0	0	0	0	9[a]	23[a]	8[a]
Total Number Operations	T_1	13	32	55	48	38	39	43	55	108	81	41	32	20
	T_0	1	16	60	56	34	36	23	17	96	102	66	38	8

[a] In these cases each farmer performed one and only one operation per crop season, so the total number of operations corresponds to the total number of farms (T_1 = 39 farms and T_0 = 40 farms). In the other cases a given farmer may perform none or several operations, ie. he may not apply any insecticide at all or may make several applications.

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia 1975-1976.

GRAPH 2. SEASONAL DISTRIBUTION OF MAIZE BEANS PRODUCTION OPERATIONS FOR RIONEGRO BY TYPE OF TECHNOLOGY



1/ A completed process of land preparation, a planting, a weeding, a fertilizer application, an insecticide application, and a completed harvesting are each called an "operation." Some operations are always performed once and only once in a crop season. Others may not be performed at all by some farmers or may be performed more than once.

the maize-bean system in Rionegro presents a different time requirement than that followed in Caqueza. That is, the planting, weeding, sprayings and fertilizing operations performed for beans generate the highest level of farm operations precisely during the slack months observed in Caqueza. The agricultural year comes to an end with the harvest of both maize and beans late in October, November and December. The latter month shows one of the lowest levels of farm activity in either district.

The general effect of technological adoption on the time pattern followed among potato-peas growers (T_1 and T_0) is similar to the one depicted earlier for the maize-bean system. That is, there have not been significant shifts in the planting operation in the T_1 group. However, the pervasive climatic characteristics in the potato regions in both districts generates suitable environmental conditions for a longer planting season (Tables 5 and 6). The figures in both tables indicate that land preparation and planting operations are performed during the months of January through July for the agricultural year sampled. However, this finding does not preclude the possibility that some farms could be planting during the remaining months. It is common to see potato fields at every stage of their vegetative period during most of the year.

This characteristic of the potato zone has a crucial impact upon seasonality of labor needs. A shorter vegetative period accompanied by high frequency of chemical sprayings,[1/] leads to the more uniform time pattern observed in both Districts. This phenomenon is evident in Graphs 3 and 4. The sprayings of chemicals reached eight applications per crop in nearly ninety per cent of the cases. This operation was repeated at intervals of about sixteen days.

Potato growers still, however, experience periods of higher than average labor demands. Peak demand periods occur in the periods March through May and July through September for the Caqueza district and May through August in Rionegro. Nonetheless these periods are neither preceded nor succeeded by really slack activity months, such as it was observed in the case of maize farmers in Caqueza.

[1/] It ought to be noted that the frequency of spraying is directly correlated to the amount and frequency of rainfall.

TABLE 5

THE TIMING OF PRODUCTION OPERATIONS IN POTATO-PEAS PRODUCTION IN THE CAQUEZA DISTRICT

Operations	Type of Technology	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Number of Operations											
Land Preparation	T_1	4[a]	5[a]	0	4[a]	3[a]	5[a]	7[a]	0	0	0	0	0
	T_0	7[a]	1[a]	7[a]	0	7[a]	7[a]	5[a]	0	0	0	0	0
Planting	T_1	5[a]	1[a]	2[a]	6[a]	4[a]	1[a]	9[a]	0	0	0	0	0
	T_0	5[a]	4[a]	4[a]	3[a]	5[a]	2[a]	11[a]	0	0	0	0	0
Weedings	T_1	9	9	2	4	9	8	8	13	10	6	0	0
	T_0	12	6	11	6	8	7	11	11	16	6	0	0
Fertilizing	T_1	6	6	6	13	10	3	9	8	6	8	0	0
	T_0	9	7	8	7	9	2	5	6	7	8	0	0
Sprayings	T_1	5	11	14	17	29	21	35	39	28	15	18	0
	T_0	5	14	22	22	20	31	39	40	36	20	22	0
Harvesting	T_1	0	0	0	1[a]	3[a]	2[a]	1[a]	0	5[a]	8[a]	3[a]	5[a]
	T_0	0	0	0	4[a]	5[a]	0	2[a]	3[a]	5[a]	4[a]	5[a]	6[a]
Total Number of Operations	T_1	29	32	24	45	58	40	69	60	49	37	21	5
	T_0	38	32	52	52	63	49	73	60	64	38	27	6

[a] In these cases each farmer performed one and only one operation per crop season, so the total number of operations corresponds to the total number of farms (T_1 = 28 farms and T_0 = 34 farms). In the other cases a given farmer may perform none or several operations, ie. he may not apply any insecticide at all or may make several applications.

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia, 1975-1976.

TABLE 6

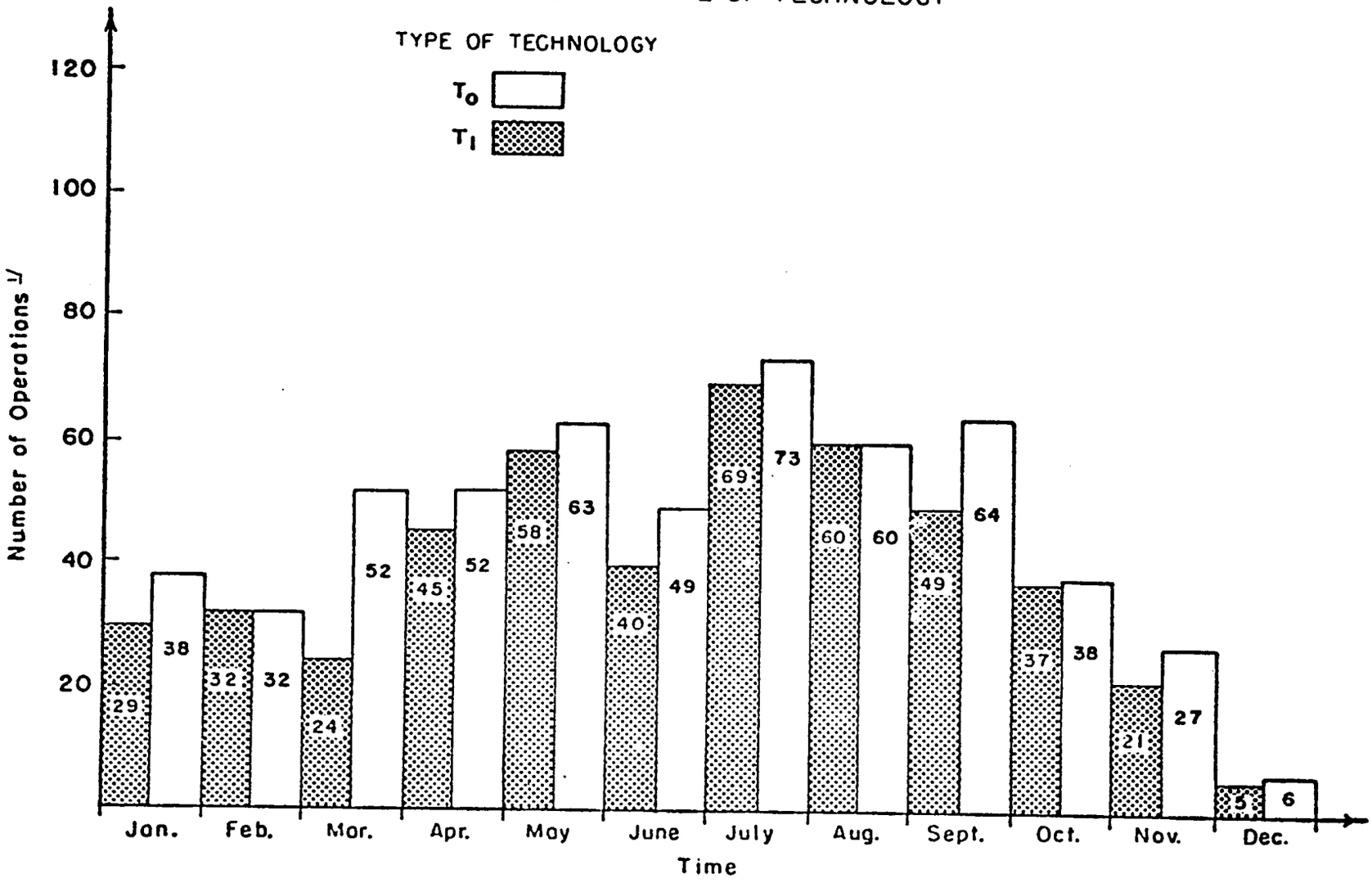
THE TIMING OF PRODUCTION OPERATIONS IN POTATO-PEAS IN THE RIONEGRO DISTRICT

Operation	Type of Technology	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Number of Operations											
Land Preparation	T_1	7[a]	3[a]	3[a]	5[a]	4[a]	6[a]	10[a]	0	0	0	0	0
	T_0	12[a]	2[a]	4[a]	6[a]	3[a]	9[a]	4[a]	0	0	0	0	0
Planting	T_1	7[a]	3[a]	1[a]	4[a]	5[a]	9[a]	10[a]	0	0	0	0	0
	T_0	9[a]	5[a]	1[a]	8[a]	2[a]	5[a]	10[a]	0	0	0	0	0
Weedings	T_1	5	11	4	5	5	9	12	14	2	8	0	0
	T_0	4	9	12	3	11	8	8	13	6	0	0	0
Fertilizing	T_1	23	12	3	8	18	38	22	12	8	7	0	0
	T_0	21	13	6	12	11	18	29	12	3	1	0	0
Sprayings	T_1	7	7	21	30	27	25	46	48	48	43	10	0
	T_0	9	9	29	46	41	31	45	34	34	32	10	0
Harvesting	T_1	0	0	0	0	7[a]	3[a]	2[a]	5[a]	1[a]	1[a]	10[a]	10[a]
	T_0	0	0	0	0	9[a]	2[a]	8[a]	2[a]	2[a]	1[a]	7[a]	9[a]
Total Number of Operations	T_1	49	36	32	52	66	80	102	79	59	51	20	10
	T_0	55	38	62	75	77	73	114	61	45	34	17	9

[a] In these cases each farmer performed one and only one operation per crop season, so the total number of operations corresponds to the total number of farms (T_1 = 38 farms and T_0 = 40 farms). In the other cases a given farmer may perform none or several operations, ie. he may not apply any insecticide at all or may make several applications.

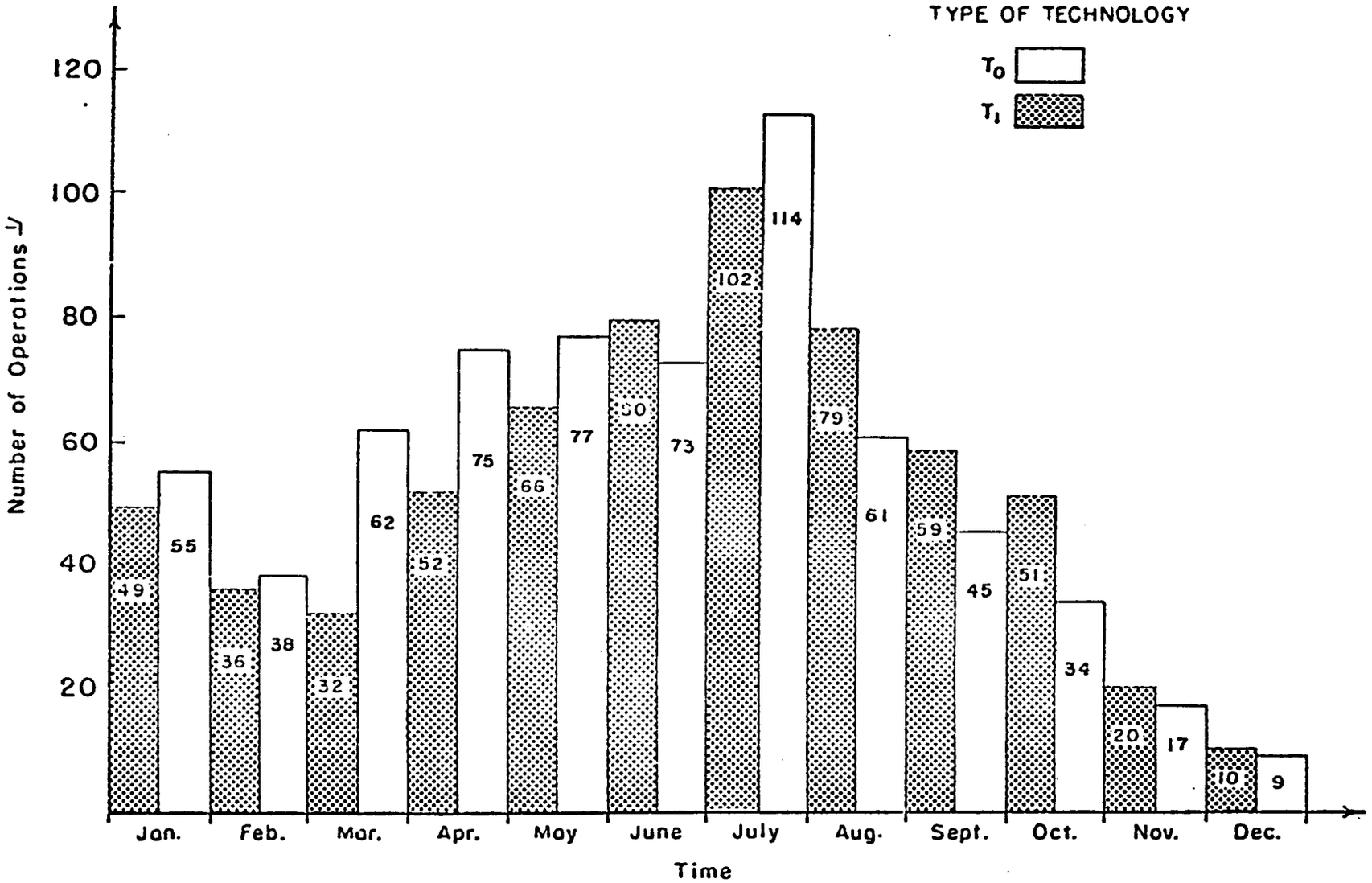
SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 3. SEASONAL DISTRIBUTION OF POTATO-PEAS PRODUCTION OPERATIONS FOR FARMS IN CAQUEZA BY TYPE OF TECHNOLOGY



1/ A completed process of land preparation, a planting, a weeding, a fertilizer application, an insecticide application, and a completed harvesting are each called an "operation." Some operations are always performed once and only once in a crop season. Others may not be performed at all by some farmers or may be performed more than once.

GRAPH 4. SEASONAL DISTRIBUTION POTATO-PEAS PRODUCTION OPERATIONS FOR FARMS IN RIONEGRO BY TYPE OF TECHNOLOGY



1/ A completed process of land preparation, a planting, a weeding, a fertilizer application, an insecticide application, and a completed harvesting are each called an "operation." Some operations are always performed once and only once in a crop season. Others may not be performed at all by some farmers or may be performed more than once.

QUANTITY OF TOTAL LABOR USED AND ITS CHANGES DUE TO THE ADOPTION OF NEW TECHNOLOGIES

The observed differences in quantity of labor used between the traditional farmers (T_0) and those who adopted new technology (T_1) are presented next.

Maize-Beans in Caqueza

The figures in Table 7 show a remarkably larger amount of total labor used per hectare by farmers with modern technologies. Those operations directly related to the adoption of new technologies such as application of fertilizers, insecticides and a larger quantity of seed present the largest differences in use of labor. Although, there are no procedural differences in land preparation *per se* the two groups (T_1, T_0) present a clear distinction in use of labor for this operation. T_1 shows over twenty-five percent more use of labor. This fact might be related to a closer supervision by the ICA Agronomist of those farmers in the former group or perhaps a higher degree of motivation among them.

The planting operation shows a 16 percent larger use of labor by the T_1 farmers. This phenomenon can be easily understood since this group uses on the average almost twenty percent more seed per hectare (Table 8). The weeding operations also require more labor.[1/] This difference of nearly twenty-two percent could be due to the impact that fertilizers have on the growth of weeds. The most dramatic change observed in labor requirements is in the use of insecticides and fungicides. This is due to the fact that farmers in the T_0 group rarely use any chemicals. The fertilizing operation also presents a remarkable impact upon labor requirements, so it is possible to observe almost a four-fold increase in labor requirements for T_1 (Graph 5). This figure is consistent with the one displayed in Table 8 for this group showing the tremendous shift (481.59%) in fertilizer expenditure per hectare. Finally, the harvesting operation presents a remarkable difference. This is to be expected since the maize production differed by 165% between T_1 and T_0 (Table 8). Most of this labor increase is due to the maize crop, since beans play an insignificant role for the farmers in Caqueza.

1/ The higher use of labor for weeding purposes could reflect, in part at least, higher levels of motivation on the part of farmers who adopted new technology.

TABLE 7

MAN-DAYS PER HECTARE OF LABOR USED FOR SPECIFIED OPERATIONS IN MAIZE-BEAN PRODUCTION BY MODERN AND TRADITIONAL METHODS IN CAQUEZA

Operation	Traditional Technology (T_0)	Modern Technology (T_1)	Percentage Change
	Man-days of labor		
Land Preparation	5.90	7.54	27.80
Planting	5.00	5.84	16.80
Weeding	28.00	34.00	21.43
Fertilizing	2.10	8.10	285.71
Chemical Applications	0.87	5.58	541.38
Harvesting	9.50	18.00	89.47
Total	51.37	79.06	53.90

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

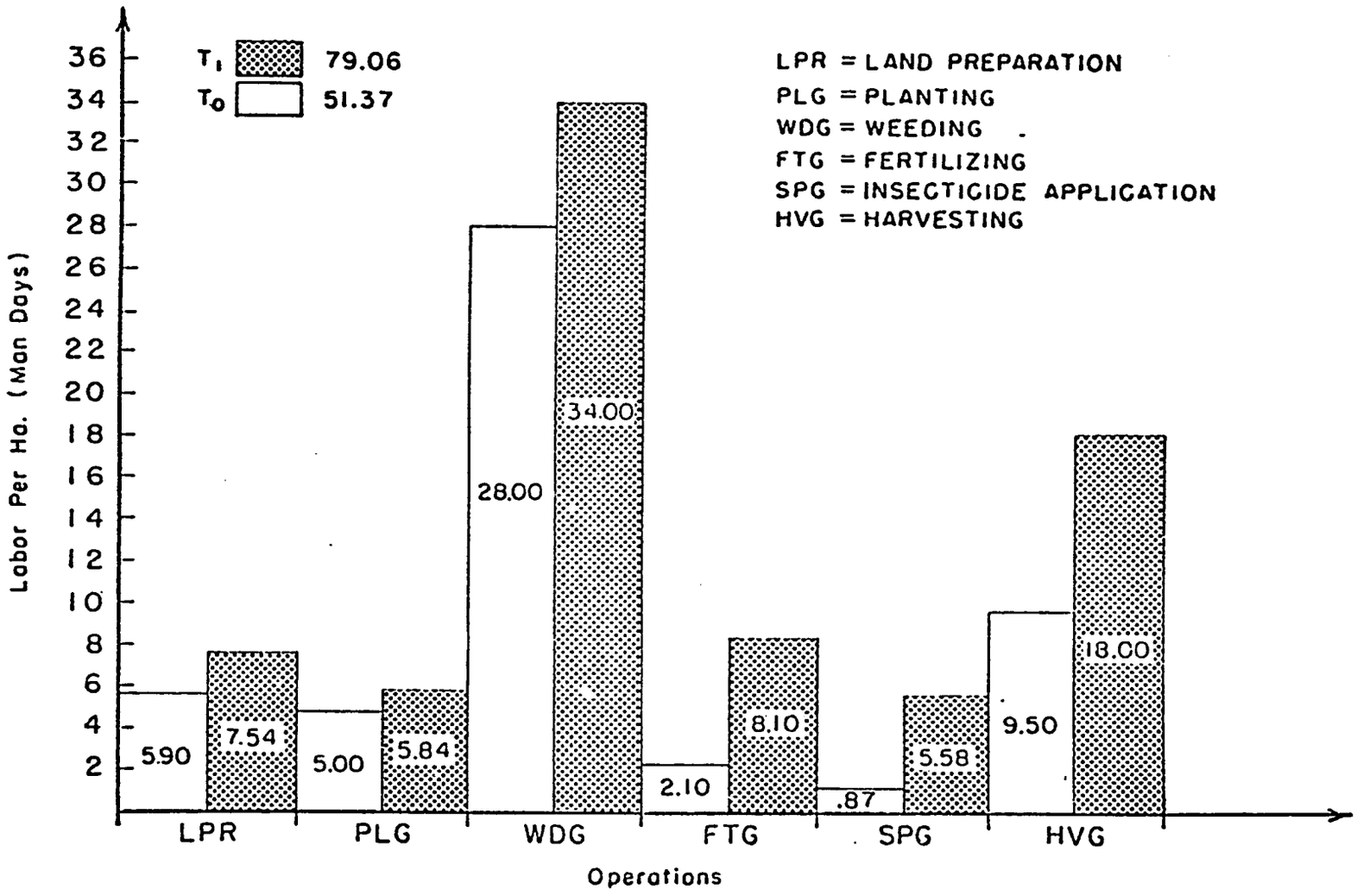
TABLE 8

MAIZE-BEAN AVERAGE INPUT AND OUTPUT FIGURES PER HECTARE FOR CAQUEZA

Type of Technology	Seed (KLS)	Value Fertilizer ($)	Value INS/FNG ($)	Maize Production (KLS)	Beans Production (KLS)	Total Labor (Man-days)
Traditional	19.00	424.20	43.90	911.82	223.23	51.37
Modern	22.68	2467.10	487.10	2418.00	450.81	79.86
Percent Change	+19.37	+481.59	+1009.57	+165.18	+101.95	+55.46

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 5. MAIZE-BEANS TOTAL LABOR USE DIFFERENCE PER HECTARE BY OPERATION IN CAQUEZA



Maize-Beans in Rionegro

The total labor differences in the maize-bean system observed in Rionegro are less impressive than the ones just reviewed for Caqueza. The difference is the result of the crucial divergence in the treatment of beans. As shown by Table 9 the total labor requirements differed by 28.30% between T_0 and T_1. Planting labor demand changes by nearly eighteen percent, and this upward shift is a normal response to an almost thirty percent increase in the quantity of seed used by the T_1 group (Table 10). The labor force required for weeding and spraying operations for T_0 and T_1 is remarkably larger than the one needed in Caqueza (Graph 6). This difference is the result of the different importance given to beans. The weeding labor requirement was augmented by almost thirteen percent.

The only dramatic difference observed between the two groups in Rionegro is the one related to the labor requirements for fertilizer applications. This increment surpassed the one hundred percent mark. Finally, the harvesting operation also presents an upward shift of over fifty percent in labor demand. The labor requirement for harvesting in Rionegro is noticeably higher than that for Caqueza. This difference is due mostly to the greater production levels for both maize and beans attained in this district.

Potato-Peas in Caqueza

Although the difference in the total labor demand for the potato-peas system due to new technology are less impressive than the ones just presented for maize-beans, they are indeed a contributing factor in decreasing the unemployment problem pervasive in these regions.

The figures in Tables 11 and 12 present the two groups T_0 and T_1 with comparatively minor differences. This is due to the overriding importance given by both groups to disease and pest control; that is there is an absolute need for using a "minimum critical level" of fungicides and pesticides. Consequently, negligible spraying differences are observed between these two groups. This required minimum critical level of chemicals leaves a nominal flexibility of choice to the farmer for using fungicides and insecticides.

Table 11 presents the total labor changes for potato-peas in Caqueza. The total observed change due to new technologies surpassed fifteen percent

TABLE 9

MAN-DAYS PER HECTARE OF LABOR USED FOR SPECIFIED OPERATIONS IN MAIZE-BEAN PRODUCTION BY MODERN AND TRADITIONAL METHODS IN RIONEGRO

Operation	Traditional Technology (T_0)	Modern Technology (T_1)	Percentage Change
	Man-days of labor		
Land Preparation	11.90	17.50	47.05
Planting	4.00	4.70	17.50
Weeding	50.80	57.40	12.99
Fertilizing	4.90	10.10	106.12
Chemical Applications	15.00	15.30	2.00
Harvesting	21.50	33.70	56.74
Total	108.10	138.70	28.30

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

TABLE 10

MAIZE-BEAN AVERAGE INPUT AND OUTPUT FIGURES PER HECTARE FOR RIONEGRO

Type of Technology	Seed (KLS)	Value Fertilizer ($)	Value INS/FNG ($)	Maize Production (KLS)	Beans Production (KLS)	Total Labor (Man-days)
Traditional	14.72	1390.10	286.30	1184.00	442.40	108.10
Modern	19.00	4611.90	792.20	2656.50	1004.40	138.70
Percent Change	+29.07	+231.80	+176.70	+124.45	+124.03	+28.30

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 6. MAIZE-BEANS TOTAL LABOR USE DIFFERENCE PER HECTARE BY OPERATION IN RIONEGRO

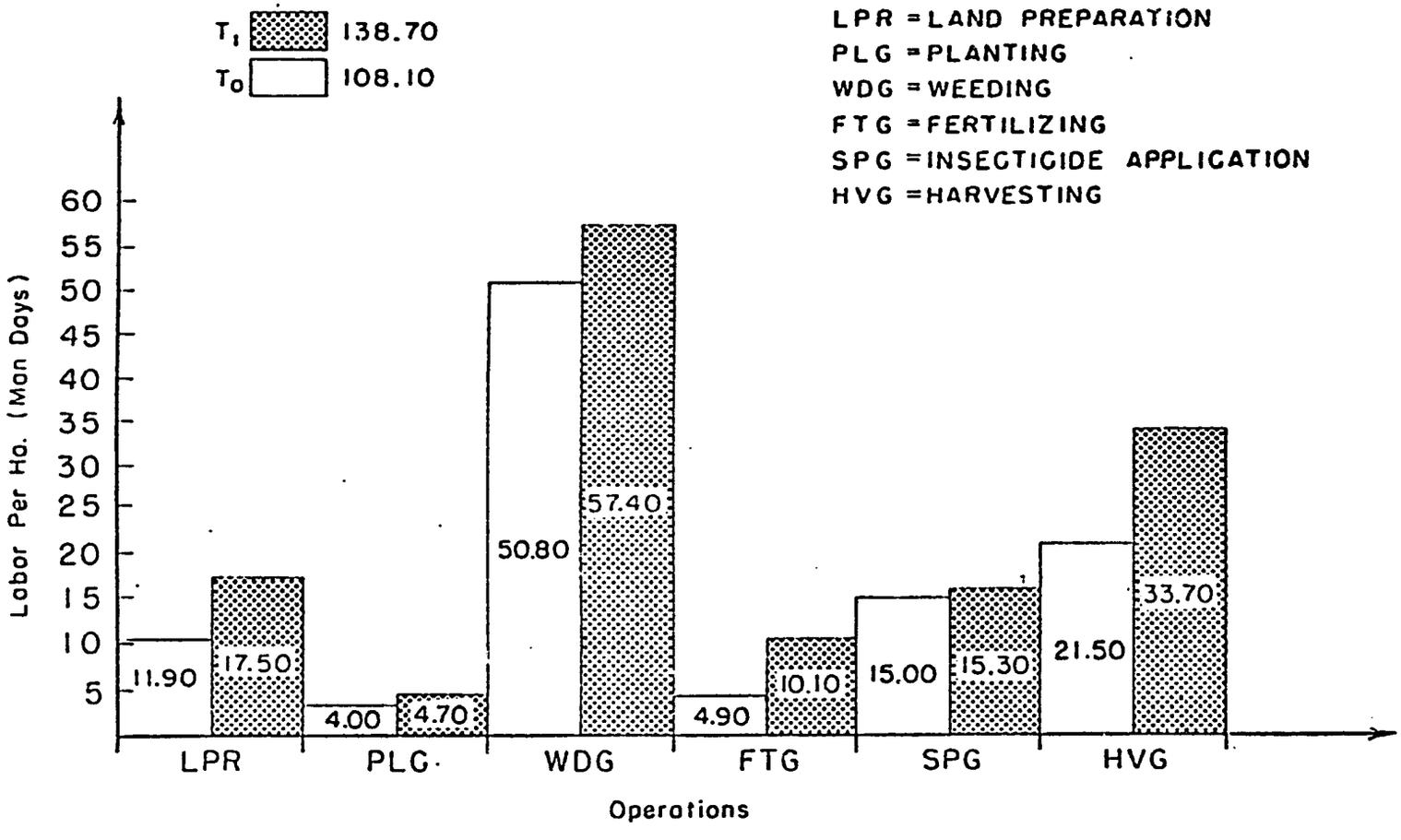


TABLE 11

MAN-DAYS PER HECTARE OF LABOR USED FOR SPECIFIED OPERATIONS IN POTATO-PEAS PRODUCTION BY MODERN AND TRADITIONAL METHODS IN CAQUEZA

Operation	Traditional Technology	Modern Technology	Percentage Change
	Man-days of labor		
Land Preparation	12.70	18.00	41.73
Planting	20.15	24.20	20.01
Weeding	31.60	32.82	3.90
Fertilizing	9.40	13.20	40.42
Spraying	28.50	29.50	2.86
Harvesting	46.10	53.40	15.84
Total	148.45	171.12	15.27

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

TABLE 12

MAN-DAYS PER HECTARE OF LABOR USED FOR SPECIFIED OPERATIONS IN POTATO-PEAS PRODUCTION BY MODERN AND TRADITIONAL METHODS IN RIONEGRO

Operation	Traditional Technology	Modern Technology	Percentage Change
	Man-days of labor		
Land Preparation	33.00	27.60	-16.36
Planting	13.40	16.80	25.37
Weeding	27.50	33.20	20.73
Fertilizing	14.50	18.60	28.28
Spraying	22.70	25.70	13.22
Harvesting	56.10	62.00	10.51
Total	167.20	183.90	10.00

SOURCE: S. Sepulveda.- Impact of Modern Technologies Upon Employment and Factors' Return. Caqueza, Rionegro, Colombia. 1975-1976.

(Graph 7). The land preparation data indicate an almost forty-two percent larger use in seed bed preparation. For this group only six percent of the farmers used tractors to prepare the land. The planting operation shows an upward shift of twenty percent in the demand for labor in the T_1 group. This difference is compatible with the figure in Table 13 indicating a rise of over forty percent in the quantity of seed used by the T_1 group. The most striking increment of total labor used is generated by the larger use of fertilizer, observed in Table 13. Finally, labor use for harvesting was increased by almost sixteen percent. This large single figure observed in the harvesting operation is a composite derived from labor used for harvesting, washing, selecting, packing and transporting the potatoes.

Potato-Peas in Rionegro

The labor demand picture for potatoes in Rionegro follows basically the same pattern as in Caqueza (Graph 8). The figures in Table 12 indicate a decline of more than sixteen percent in total labor demanded for land preparation. This decrease is consonant with the fact that thirty-five percent of the farmers in this group used tractors. Hence, this drop in labor use corresponds to a higher degree of tractorization in Rionegro. The planting operation shows a difference of nearly twenty-one percent. This gain is generated by an increase of nearly fifty percent in the quantity of seed used by the T_1 group (Table 14). The largest upward shift in labor demand observed in this district is due to a tremendous difference in fertilizer used (over one hundred percent) as shown in Table 14.

Although there is an increase of almost ninety percent in potato production, there is a recorded gain of a bit over ten percent on labor demand for the harvest operation. This phenomenon might be generated by the size of the potato harvest, i.e. the T_1 group planted improved seed varieties which produced larger size tubers, as well as a smaller percentage of riche (the smallest size of tuber used for animal and family consumption rather than for sale).

CHART 7. POTATO-PEAS TOTAL LABOR DIFFERENCE PER HECTARE BY OPERATION IN CAQUEZA

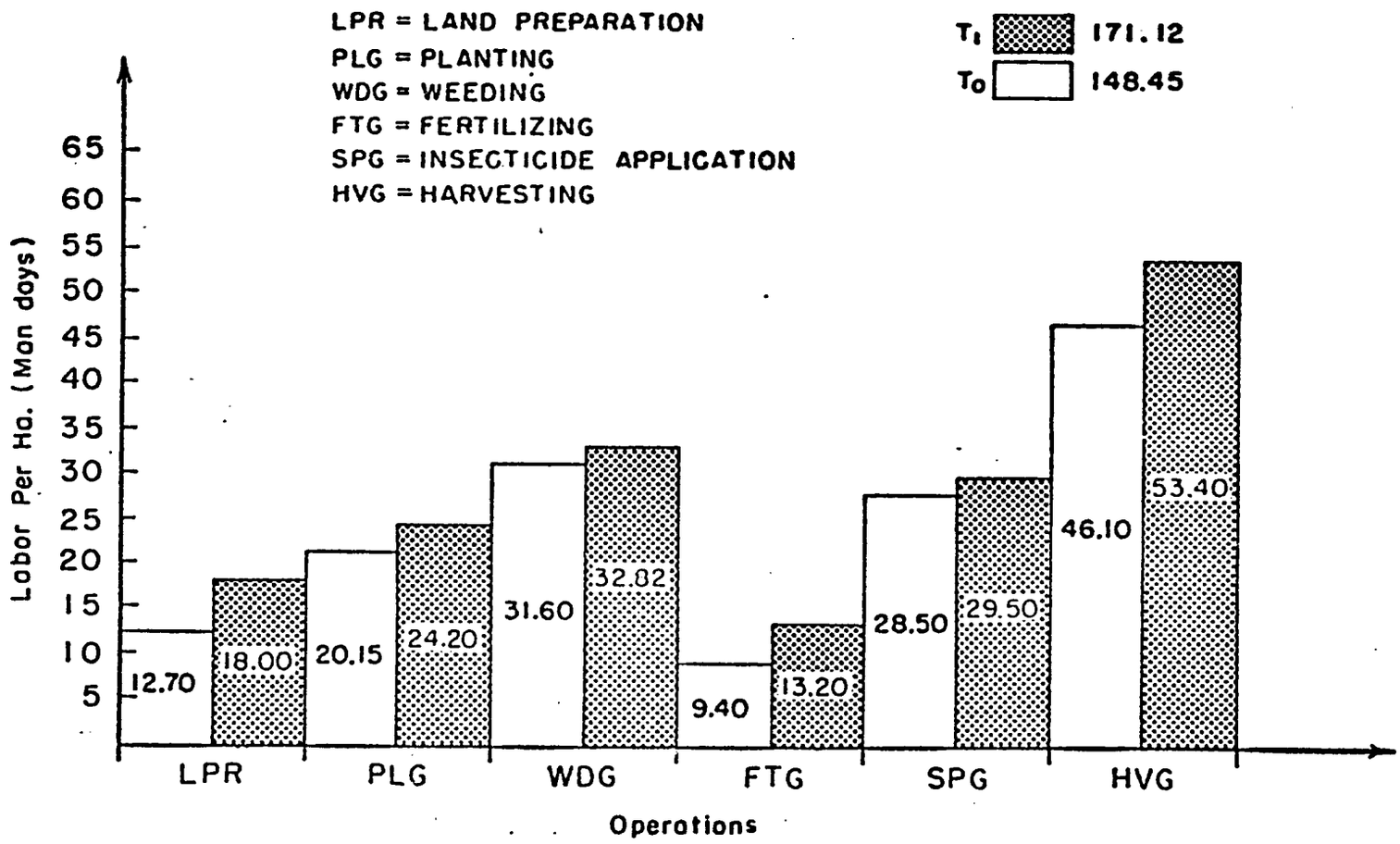


TABLE 13

POTATO-PEAS AVERAGE INPUT AND OUTPUT FIGURES PER HECTARE FOR CAQUEZA

Type of Technology	Seed (KLS)	Value Fertilizer ($)	Value INS/FNG ($)	Potato Production (KLS)	Peas Production (KLS)	Total Labor (Man-days)
Traditional	686.00	5597.10	2684.90	8394.00	418.51	148.45
Modern	971.00	12525.14	2704.95	11847.00	628.40	171.12
Percent Change	+41.55	+123.78	+0.75	+41.14	+50.52	+15.27

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976

GRAPH 8. POTATO-PEAS TOTAL LABOR USE DIFFERENCE PER HECTARE BY OPERATION IN RIONEGRO

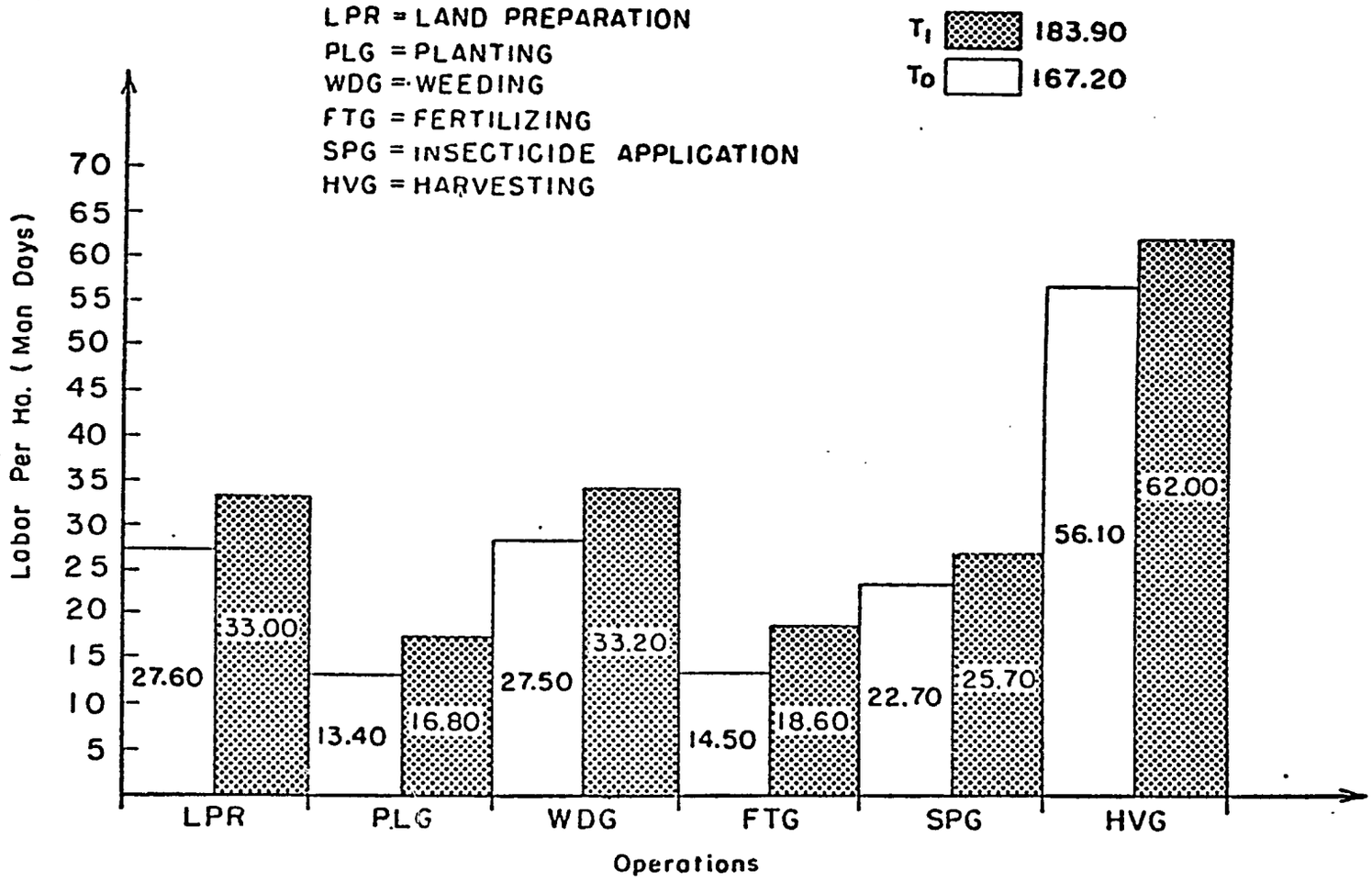


TABLE 14

POTATO-PEAS AVERAGE INPUT AND OUTPUT FIGURES PER HECTARE FOR RIONEGRO

Type of Technology	Seed (KLS)	Value Fertilizer ($)	Value INS/FNG ($)	Potato Production (KLS)	Peas Production (KLS)	Total Labor (Man-days)
Traditional	812.00	8139.20	1326.60	9889.00	512.31	167.20
Modern	1205.00	16341.80	1743.50	18723.00	754.08	183.90
Percent Change	+48.40	+100.78	+31.43	+89.33	+47.19	+10.00

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

COMPOSITION OF THE LABOR FORCE AND ITS CHANGES DUE TO THE ADOPTION OF NEW TECHNOLOGIES

It was shown at the beginning of this section that new technology generates increases in the demand for labor that basically follow the same seasonal distribution patterns as those for traditional technology. We might expect that this would lead to changes in the composition of the labor force.

Increases in the demand for labor can be satisfied from three possible sources: (i) family; (ii) exchanged; and (iii) hired labor. The new technology may demand readjustments among these that could, in the long run, be a hindrance to further use of modern technology. If, for example, the farmer must rely on greater amounts of hired labor, which demands prompt cash payments, he may encounter cash flow problems. Farms in the maize zone of Caqueza use a large amount of exchange labor. This latter source of manpower is in effect an intertemporal transfer of family labor. This transfer of services does not involve a transfer of cash but return of labor. This labor is paid for almost immediately and often by performing the same task in return.

Maize-Beans Labor Force in Caqueza

The per hectare changes within the labor force in Caqueza are shown in Table 15. The higher labor demand in land preparation with the new technologies is clearly satisfied by family labor, which shows an increase of one hundred fifty percent, while hired labor increased only about fourteen percent. This could be the result of a flexibility in the time period in which this operation can be achieved successfully. The opposite is true, however, during the planting operation. That is, the need for an expedited planting operation demands the presence of a large number of laborers in a specific short period. This demand can be satisfied only through increases in the hired component of the labor force. The planting operation for both groups takes place in a shorter time span than land preparation.

Exchange labor appears in the weeding and fertilizer operations (Graph 9). Weeding shows an increase in all three types of labor as the result of technological change. Also, the fertilizing operation shows

TABLE 15

CHANGES IN THE MAIZE-BEANS LABOR FORCE FOR CAQUEZA

Operation	Type of Labor	Traditional Technology		Modern Technology		Percentage Change
		Man-days per hectare				
Land Preparation	Family	0.60		1.50		150.00
	Exchange	0.00		0.00		---
	Hired	5.30		6.04		13.96
Planting	Family	3.30		1.82		44.85
	Exchange	0.00		0.00		---
	Hired	1.70		4.02		136.47
Weeding	Family	9.20		10.40		13.04
	Exchange	11.28		14.16		25.53
	Hired	7.52		9.44		25.53
Fertilizing	Family	0.90		2.90		222.22
	Exchange	0.36		1.56		333.33
	Hired	0.84		3.64		333.33
Chemicals	Family	0.42		4.73		1226.20
	Exchange	0.00		0.00		---
	Hired	0.45		0.85		88.89
Harvesting	Family	6.00		5.40		-10.00
	Exchange	0.00		0.00		---
	Hired	3.50		12.60		260.00
Total Labor Used	Family	20.42	39.75%	26.75	33.83%	
	Exchanged	11.64	22.65%	15.72	19.88%	
	Hired	19.31	37.60%	36.59	46.29%	
	All	51.37	100.00%	79.06	100.00%	

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 9. CHANGES IN THE MAIZE-BEANS LABOR FORCE FOR CAQUEZA

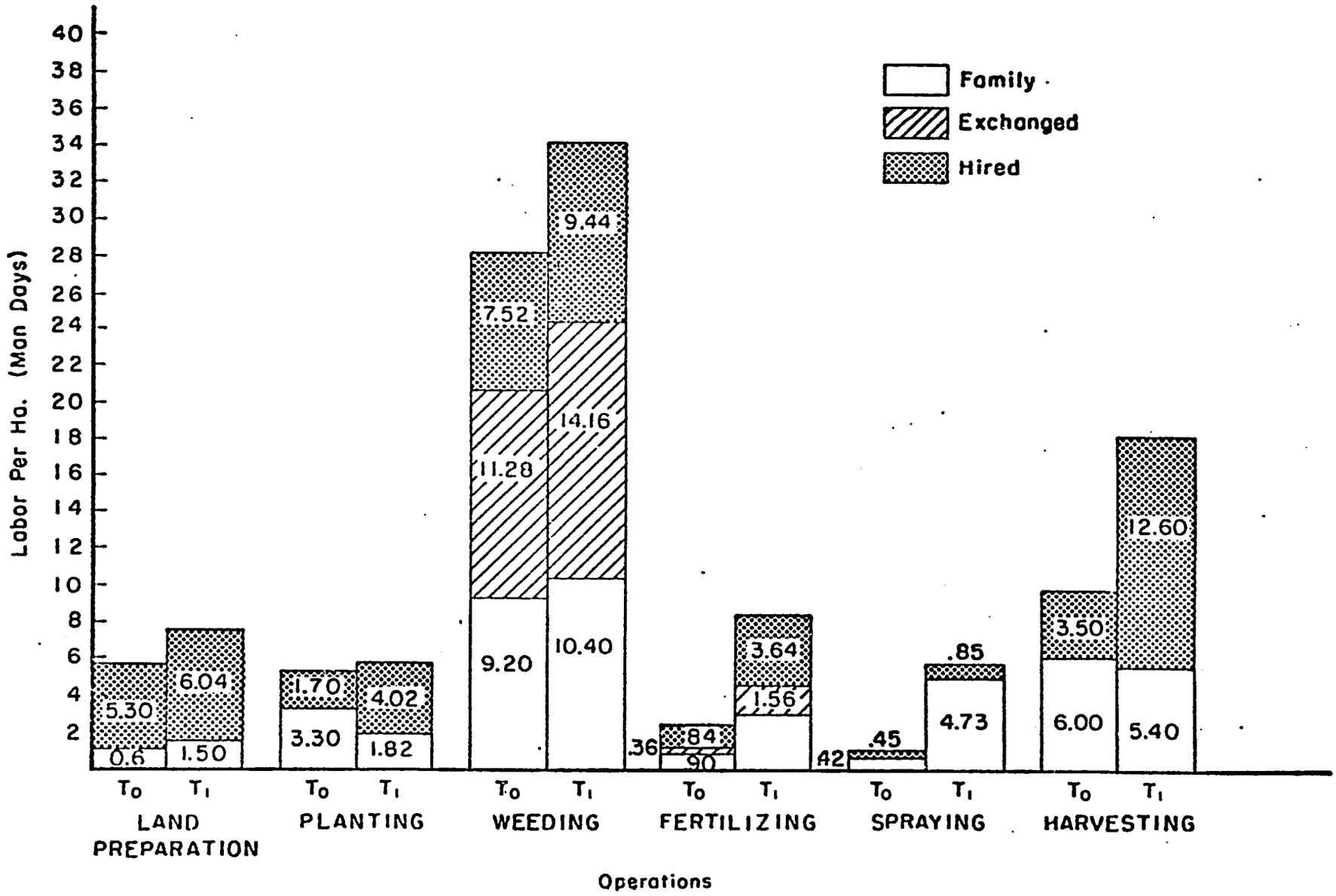


TABLE 16

CHANGES IN THE MAIZE-BEANS LABOR FORCE FOR RIONEGRO

Operation	Type of Labor	Traditional Technology		Modern Technology		Percentage Change
		Man-days per hectare				
Land Preparation	Family	11.20		12.10		8.04
	Hired	0.70		5.40		671.43
Planting	Family	3.60		3.50		-2.78
	Hired	0.40		1.20		200.00
Weeding	Family	41.60		41.20		-0.96
	Hired	9.20		16.20		76.09
Fertilizing	Family	0.00		1.70		---
	Hired	4.90		8.40		71.43
Chemicals	Family	14.70		11.50		-21.77
	Hired	0.30		3.80		1166.67
Harvesting	Family	18.00		20.50		13.89
	Hired	3.50		13.20		277.14
Total Labor Used	Family	89.10	82.42%	90.50	65.25%	
	Hired	19.00	17.58%	48.20	34.75%	
	All	108.10	100.00%	158.70	100.00%	

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 6.10. CHANGES IN THE MAIZE-BEANS LABOR FORCE FOR RIONEGRO

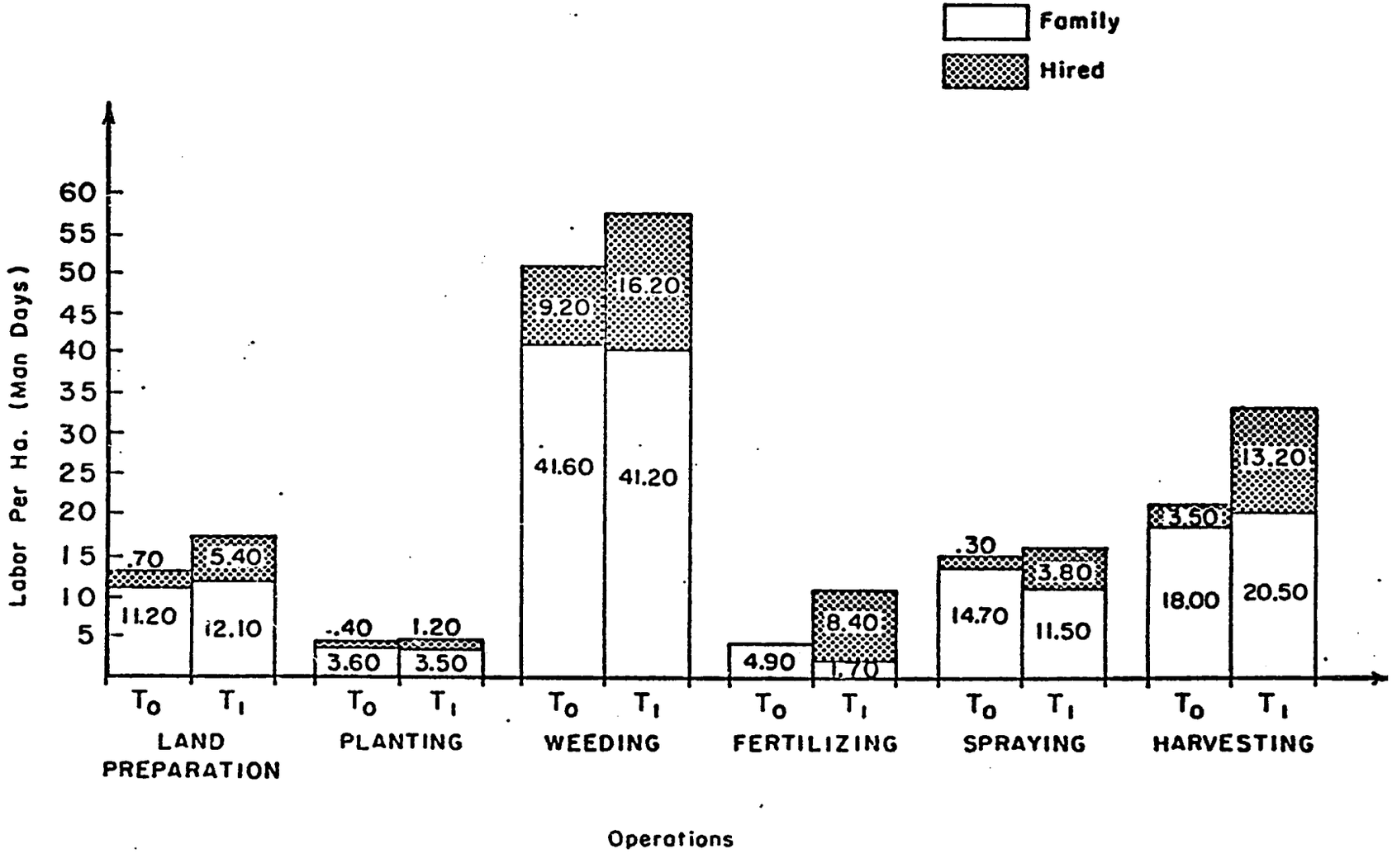


TABLE 17

CHANGES IN THE POTATO-PEAS LABOR FORCE IN CAQUEZA

Operation	Type of Labor	Traditional Technology		Modern Technology		Percentage Change
		Man-days per hectare				
Land Preparation	Family	5.40		2.70		-50.00
	Hired	7.30		15.30		109.60
Planting	Family	6.10		4.80		-21.30
	Hired	18.10		19.40		7.18
Weeding	Family	13.10		6.70		-48.85
	Hired	33.50		41.70		24.48
Fertilizing	Family	1.70		2.10		23.53
	Hired	7.70		11.10		44.16
Spraying	Family	23.30		23.60		1.29
	Hired	15.20		16.00		5.26
Harvesting	Family	7.80		14.20		82.05
	Hired	42.30		39.20		-7.32
Total Labor Used	Family	57.40	31.63%	54.10	27.49%	
	Hired	124.10	68.37%	142.70	72.51%	
	All	181.50	100.00%	196.80	100.00%	

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH II. CHANGES IN THE POTATO-PEAS LABOR FORCE FOR CAQUEZA

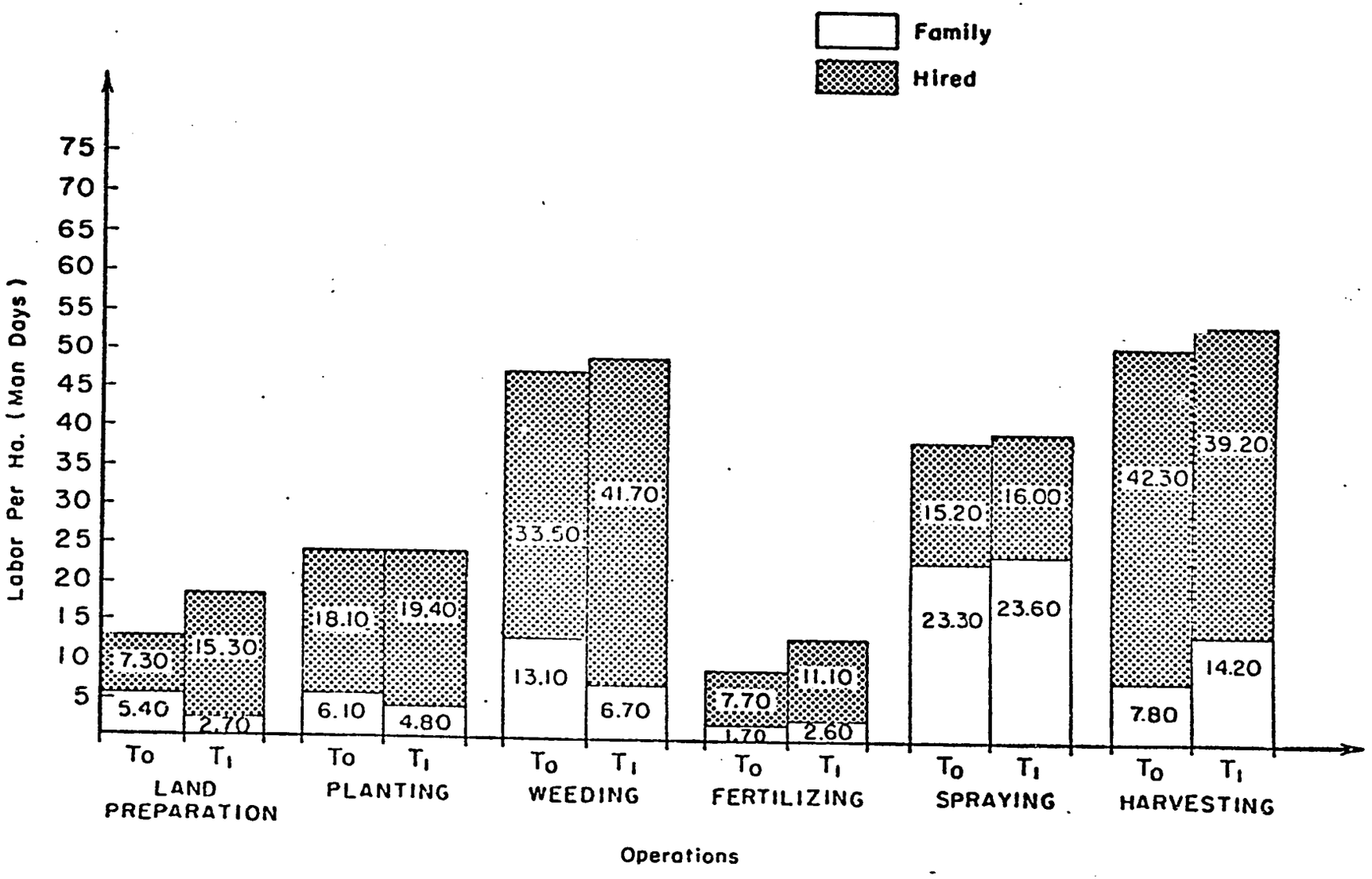


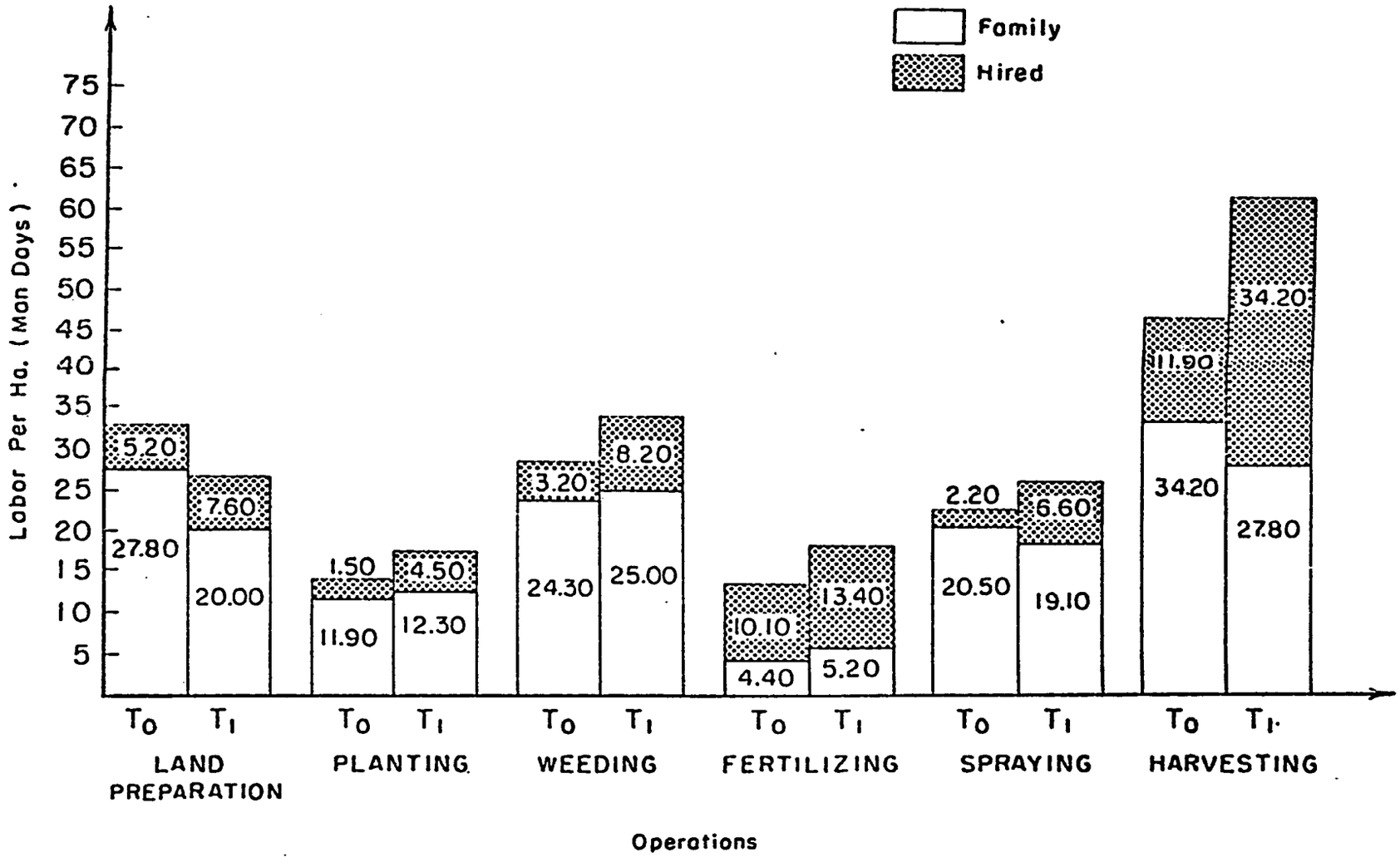
TABLE 18

CHANGES IN THE POTATO-PEAS LABOR FORCE IN RIONEGRO

Operation	Type of Labor	Traditional Technology		Modern Technology		Percentage Change
		Man-days per hectare				
Land Preparation	Family	27.80		20.00		-28.06
	Hired	5.20		7.60		46.15
Planting	Family	11.90		12.30		3.36
	Hired	1.50		4.50		200.00
Weeding	Family	24.30		25.00		2.88
	Hired	3.20		8.20		156.25
Fertilizing	Family	4.40		5.20		18.18
	Hired	10.10		13.40		32.67
Spraying	Family	20.50		19.10		-6.83
	Hired	2.20		6.60		200.00
Harvesting	Family	34.20		27.80		-18.71
	Hired	11.90		34.20		187.39
Total Labor Used	Family	123.10	78.31%	109.40	59.49%	
	Hired	34.10	21.69%	74.50	40.51%	
	All	157.20	100.00%	183.90	100.00%	

SOURCE: S. Sepulveda. Impact of Modern Technologies Upon Employment and Factors' Return. Survey. Caqueza, Rionegro, Colombia. 1975-1976.

GRAPH 12. CHANGES IN THE POTATO-PEAS LABOR FORCE FOR RIONEGRO



SUMMARY AND IMPLICATIONS

Instituto Colombiano Agropecuario has made a conscious effort to introduce output increasing, non-labor displacing technologies on the Rural Development Projects it has undertaken since 1975. This study examined the differences in output and labor use for maize-beans and potato-peas between farmers who had accepted these technologies and those who had not on two projects.

The modernized farmers on these projects were found to have much higher yields for the crops studied; substantially higher inputs of materials especially seed, fertilizer and chemicals; and significantly higher use of labor. The seasonal distribution of the added labor, however, followed closely the seasonal distribution of labor on the traditional farms. The added labor inputs associated with the new technology were largely hired, rather than supplied by farm families, because of the continuance of sharp peaks in labor demand.

Modifications in the agriculture of the area that would more nearly equalize labor needs throughout the year would be very helpful. The introduction of irrigation could do this and might be an appropriate next step in technological innovation though it would require large amounts of new capital, new forms of public organization, and new farming skills. Since labor demand for maize-beans in Caqueza is especially seasonal, irrigation in that area would be especially useful. Irrigation would have the added advantage of further increasing yields for present crops, reducing yield variability from year to year, and enabling the production of some crops not now common.

Careful investigations of possibilities for introducing more livestock into small farming areas also are needed. Farmers in many areas of the world keep livestock to provide employment in periods of low need for labor on crops. Capital and some new skills would be needed for such an activity. It also would be necessary to develop new markets and marketing organizations.

Counter-seasonal nonfarm employment opportunities also would, of course, be useful. Cottage industries might be developed that would offer slack season work. Many new skills, as well as new capital, would be needed for such an undertaking.

All of these suggested measures, even if they succeeded in practice, would provide only short-run answers so long as they are carried out only by government without farmer participation in the decision-making. Small farmers must be truly integrated into the national political process; they cannot remain bystanders. A major role ought to be given to farmers as active participants in DRI planning at local and regional levels. Just shifting inputs in the direction of small farmers cannot initiate a substantial development momentum in that subsector of agriculture. The process of Integrated Rural Development must start by integrating the farmers into DRI's decision making. Equalizing access to new technology is not enough by itself.

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