THE PUEBLA PROJECT:
SEVEN YEARS OF EXPERIENCE 1967 - 1973

Analysis of a Program to Assist Small Subsistence Farmers to Increase Crop Production in a Rainfed Area of Mexico

PARTICIPATING INSTITUTIONS

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Ministry of Agriculture, Government of Mexico
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COORDINATION OF THE TECHNICAL PROGRAM

International Maize and Wheat Improvement Center (CIMMYT)
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OPERATION (Fertilization Committee of the State of Puebla)

Ministry of Agriculture
Government of the State of Puebla
The national fertilizer company, "Guanos y Fertilizantes"
Ministry of Water Resources
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National Agricultural Credit Bank
National Ejidal Credit Bank
Agricultural Bank of the South
League of Agrarian Communities
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National Marketing Agency
Fertilizer distributor, "Impulsora de Puebla"
Fertilizer distributor, "Agrónomos Unidos"
Fertilizer distributor, "Fertilizantes Olmeca"
Fertilizer distributor, "Fertiton de Puebla"

Preface

This report documents the first seven years of the Puebla Project – its philosophy, objectives, organization, operation and accomplishments. It was prepared by staff members and advisors, most of whom have been associated with the Project since its beginning.

In analysing progress during these initial years, this report reflects the Project's multidisciplinary team approach. An introductory section states Project objectives, initial conceptualization, and the prerequisites for locating the Project area. The characteristics of the area – its land and people – are described next, followed by an overview of the evolvement of Project operations from 1967 to 1973. Chapters 3 and 4 detail the methodologies, field operations, and accomplishments of the maize research programs; Chapters 5 and 8 describe the methodologies and field operations of the technical assistance and evaluation programs.

Subsequent discussion (Chapters 6, 7, 9, 10) provides an examination of Project activities in organizing farmers, improving the operations of service institutions, persuading farmers to adopt new technology, increasing maize yields, and improving the general well-being of the farmers. The benefits attributable to the Project are compared with costs in Chapter 11. The Puebla Project's role in getting similar programs underway in other parts of Mexico and other countries is outlined in Chapters 12 and 13. In its final chapter (14), the report seeks to summarize what has been learned about the organization and operations of successful regional agricultural development projects.

In terms of the Project's long-term goals, the operations at present are seen to be in mid-process, with contributions already extending far beyond the Puebla Valley. The initial focus on increased maize production has widened, as originally envisioned, to encompass the broader development objectives of increased net income, greater employment opportunities, and improved general welfare of rural families.

During the period covered by this report, from 1967 though 1973, the Project was administered by the International Maize and Wheat Improvement Center (CIMMYT) and operated jointly by that institution and members of the Chapingo Graduate College. In early 1974, responsibility for the Project passed to the Mexican Ministry of Agriculture where it is presently being operated by the Chapingo Graduate College. Members of the CIMMYT staff who were functioning as advisors to the Project in 1973 have moved to the Graduate College where they are continuing their advisory role to the Project and are participating in academic programs to train people in new approaches to increasing crop production and improving the quality of life in disadvantage rural areas.

Acknowledgments

The Project operations and accomplishments have depended upon the firm support of the highest authorities of the Mexican Government. The Ministry of Agriculture has given strong backing at both the federal and state levels. The Government of the State of Puebla has supported the Project as an effective means for beginning an economic and social transformation of the area. The cooperation and support of governmental authorities and private enterprises has made it possible to improve credit facilities and to make more readily available the essential inputs and services.

The Chapingo Graduate College, through its Departments of Agricultural Communications, Statistics, Soils, and Genetics, has provided advice and direct service. The National Institute of Agricultural Research, through its Maize Department, has provided genetic materials for developing new high-yielding varieties for the area. CIMMYT has provided technical advice and direct assistance through its Maize Program and Communications Department and also has provided an administrative structure with a minimum of the bureaucratic impediments that might restrict the functioning of the Project.

The Rockefeller Foundation made the initial grant for the Project and contributed a total of $559,851 (see note below) to its support during the seven-year period, 1967-1973. During this period, CIMMYT contributed $332,737 for the operation of the Project, and $32,457 was provided by the Graduate College at Chapingo and institutions in Puebla. The total operating cost of the Project for the seven years was $925,045.

Other activities related to the Project and their costs were: (1) Consulting service for the Project team -$87,166; (2) Consulting service for similar programs in Mexico and other countries -$112,390; and (3) Training of staff for other programs -$168,158. These costs for the operation of the Project and related activities do not include a charge for indirect costs (overhead).

EDITORIAL NOTE: This report was prepared by Dr. Leobardo Jiménez Sánchez, Dr. Antonio Turrent Fernández, Dr. Heliodoro Díaz Cisneros, Lic. Francisco García Hernández, Dr. Gregorio Martínez Valdés, and Dr. Reggie J. Laird, with ample assistance from other members of the Puebla Project staff.

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All references to dollars in this report are expressed in terms of United States currency.

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Contents

INTRODUCTION

World agriculture faces two problems of great urgency: the threat of an absolute shortage of food on a global scale, and the fact of continuing low incomes and malnutrition among most of the rural population.

The Puebla Project is an experiment designed to tackle both problems simultaneously by obtaining a large increase in yield of a basic food crop – in this case maize – among small farmers producing at subsistence levels with traditional methods.

Much of the world's food is now produced on small farms, where families produce mainly for human and animal consumption on the farm and have little or no surplus to sell. These families have usually been among the last to discard their traditional farming methods and few of them are quick to reap the benefits of new technology. On a world-wide basis, however, they represent a vast potential for national development.

This potential is recognized by the governments of most developing countries; but, because of limited resources and lack of knowledge about how to reach these millions of smaller farmers, the national programs to increase crop yields have usually been aimed at a relatively small number of commercial farmers. Yet attention to these families of the traditional sector is crucial for at least three reasons: (a) their farms represent an important part of the arable land in many countries; thus, yields must be increased to satisfy total food requirements, (b) in many nations most of the human resources are employed in traditional agriculture and improved agriculture is a readily available source of increased capital from within, and (c) traditional farmers make up a large portion of the population of many countries and continuous improvement in their farming techniques is essential for over-all social development.

These considerations define the need for more efficient means of providing traditional farmers with better production methods. And it is this need that focused the two initial objectives of the Puebla Project: (a) *to develop, field test, and refine a strategy for rapidly increasing yields of a basic food crop on small land holdings; and (b) to train technicians from other regions in the elements and successful use of this strategy.*

PHILOSOPHY AND ORGANIZATION

The conceptual framework of the Puebla Project was derived from several interrelated agricultural and social science disciplines, as well as from the working knowledge and field experience of the team members. It was conceived as an integrated plan of attack on the many problems limiting farmer use of adequate production technology. It was assumed that the following factors of change would need to be available in the Project area: (a) high-yielding maize varieties, (b) information on efficient production practices, (c) effective communication of agronomic information to farmers and agricultural leaders, (d) adequate supplies of agronomic inputs at easily accessible points when they are needed, (e) crop insurance, (f) favorable relationships between input costs and crop values, (g) adequate production credit at a reasonable rate of interest, and (h) accessible markets with a stable price for maize.

When the Project began, several agricultural institutions responsible for providing inputs, credit, crop insurance and markets for maize producers were already operating in Puebla. Also, the relationships between the costs of production inputs and the price of maize were thought to be satisfactory. However, only very limited results were available from trials of maize varieties and production practices, and only one extension agent was working the area.

Thus, the action program of the Puebla Project was organized initially to include four major components: (a) varietal improvement of maize, (b) research to develop efficient recommendations on maize production practices, (c) assistance to farmers in proper use of new recommendations, and (d) coordination of the activities of the service agencies, the Project team, and the farmers. Another component – socio-economic evaluation – was added during the first year.

A key concept within the philosophy of the Project has been that the production and dissemination of information are parts of a development continuum that should not be compartmentalized in program operations. Constant interaction among staff members and feedback of information have been viewed as integral functions of the Project – from planning of research through delivery of findings to farmers and evaluation of results.

Thus, it was planned that the staff consist of a small team of capable, well-trained scientists with an adequate budget and freedom to operate at any political or technical level. The team lived and worked in the Project area, cooperating closely in conducting the field trials, demonstrations, farmer meetings, etc.

The selection and training of team personnel was seen as the crucial element in determining success. The work of the team was expected to be exceptionally arduous due to heavy demands by the large numbers of farmers in the Project area. In making decisions, team members would have to take into account, simultaneously, knowledge and expectations related to weather, attitudes of farmers, institutional organization, the personal goals of individuals in key positions, and other factors. Great skill is required in assessing and giving appropriate weight to these varied and interrelated factors. Thus, strong effort was given to acquiring the services of well-trained, capable, and innovative young agriculturalists.

PREREQUISITES

Initially, the two conditions considered necessary in selecting the Project area were: an ecological environment that would permit substantial yield increases, and a political environment that would be favorable toward Project objectives.

The main requirements of the physical environment were: (a) rainfall and temperatures adequate for good-to-high maize yields. The total amount and distribution of rainfall should be such that maize would suffer severe drought damage in less than 10 percent of the years and moderate damage in no more than 30 percent of the years. There should be only light frosts, limited to the first quarter of the growing season; and (b) reasonably deep, permeable soils free from toxic amounts of salts.

The essential aspect of the political environment was that government should strongly support the Project operations and have the will and the power to modify existing policies and agencies as necessary. This factor was especially important in respect to availability of key inputs, orderly marketing of the grain, and the relationship between the cost of principal inputs and the price of grain at the farm.

As the Project has evolved, these aspects of the ecological and, to some extent, the political environments have been recognized, not as prerequisites, but as factors that influence the strategy to be used in a particular program. The basic approach used in Puebla should be applicable in most regions of the world, when adequate attention has been given to the specific environmental, social, and economic conditions in areas where the approach is to be used.

1 THE PUEBLA AREA : ITS LAND AND PEOPLE

INTRODUCTION

The area selected for the Project comprises 32 *municipios* (counties) in the western part of the State of Puebla, Mexico (Fig. 1.1). In choosing the area, the primary considerations were that it fulfill the ecological and political prerequisites cited in the Introduction to this report, and that the farming population should consist mainly of small land holders.

The Puebla area had two other characteristics that made it appropriate for the Project: (a) it comprised about 116,800 ha of cultivated land with about 80,000 ha used for maize production – it was felt that an area of this size would be adequate for studying the effectiveness of a new approach to rapidly increasing maize yields; and (b) production practices were traditional, farmer incomes were low, and most of the harvest was consumed directly on the farm.

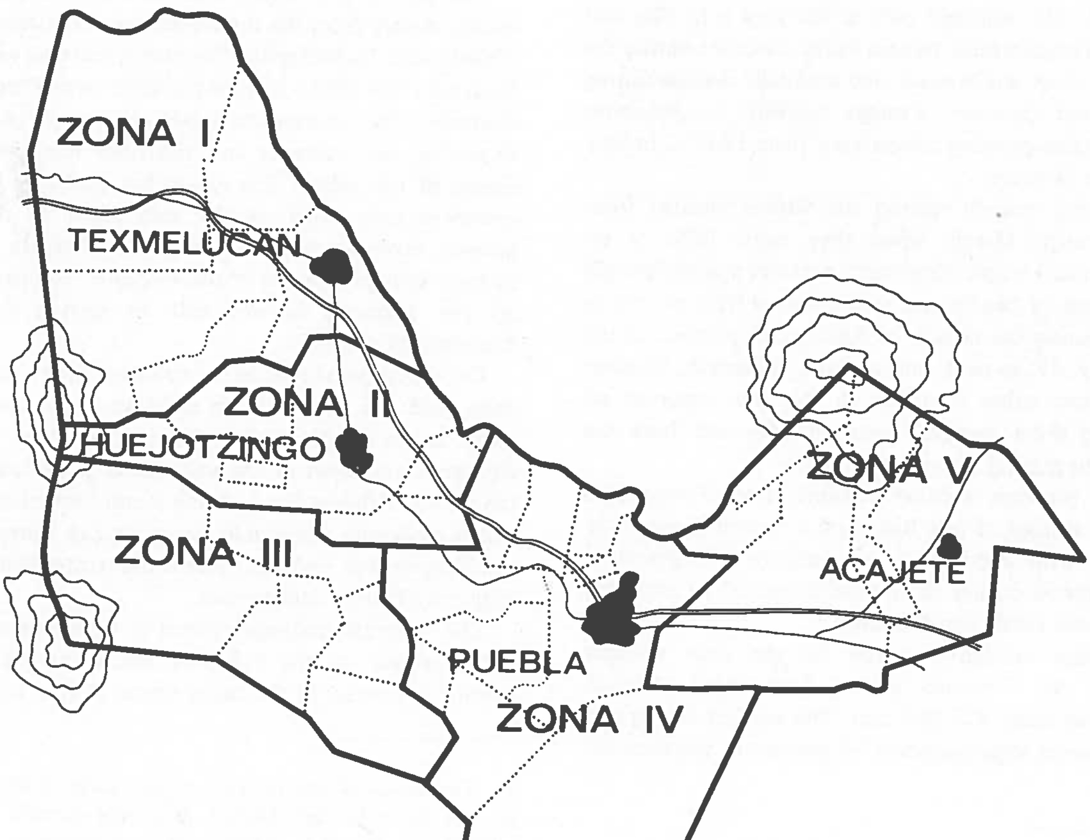

Fig. 1.1. The project area covers about 117,000 hectares of crop land in 32 municipios of the State of Puebla. As the Project evolved, the area was divided into five zones with a technical assistance agent responsible for each.

Communications within the Project area are adequate, and most villages are connected by a network of all-weather roads. The Project area is a 2-hour drive from Mexico City or the National Agricultural Center at Chapingo, and this ready accessibility allowed consultants at both locations to maintain close contact with the Project.

The remainder of this chapter describes the physical environment of the area, the farming population, local production technology, and agricultural agency services available.

PHYSICAL ENVIRONMENT

The Project area occupies much of the valley drained by the Atoyac River and lies mostly between the rising slopes of volcanos: Popocatépetl and Ixtaccihuatl to the west, and La Malinche to the north and east. It is located between latitudes 18°50' and 19° 25' north and between longitudes 97° 55' and 98°40' west of Greenwich. The lowest part of the valley lies southeast of the city of Puebla at an elevation of 2,100 m above sea level. Most of the Project area lies between 2,150 and 2,700 m above sea level, although maize is produced on the mountain slopes up to elevations of 2,900 m.

Climate [1]

The climate over most of the region is temperate with mild winters. The warmest part of the year is in May and early June. Temperatures remain fairly constant during the last of June, July, and August, and gradually decline during September and October. Average monthly temperatures during the maize-growing season vary from 18.6° C in May to 16.1° C in October.

Frosts occur mainly during the winter months from October through March, when they cause little or no damage to annual crops. However, a weather station located near the center of the Project area reported frost on one or more days during the month of April in 33 percent of the years; in May, 17 percent; and in June, 5 percent. Weather stations at two other locations in the area reported no frosts during these months. Frosts in May and June can seriously damage early plantings of maize.

Three of the four weather stations in the Puebla area reported an average of one hailstorm a month during July and August, with about half that amount in September. Severe hailstorms during these months would be expected to reduce maize yields significantly.

The average rainfall reported by the four weather stations for the 7-month period from April through October varied from 777-863 mm. The rainfall during this period represents approximately 94 percent of the total for the year.

The average rainfall in the Puebla area during the maize-growing season should be sufficient to satisfy the needs of the crop. However, drought damage to maize would be expected when: (a) the total rainfall during the year is considerably less than the average, or (b) the amounts of precipitation are well below average during the critical months of June, July, and August.

In 1967, drought intensities were estimated using existing information on soil characteristics, evapotranspiration losses, and water needs of maize at critical growth periods; and the daily rainfall data available at the four weather stations in the Project area. The drought damage, estimated for individual years, was classified as: zero or very slight; moderate; or severe. As an average for the four stations, it was estimated that there would have been zero or very slight drought damage in 60 percent of the years, moderate damage in 30 percent, and severe damage in 10 percent. Maize growing on soils with a high moisture-supplying capacity would have suffered less from drought than these percentages indicate, while maize on soils with a low moisture-supplying capacity would have suffered more. A moderate effect of drought would be expected to reduce yields by 30-60 percent; a severe effect by 60 percent or more.

Soils [2]

The soils in the Project area have formed from volcanic *ejecta*, mainly from the three volcanos: Popocatépetl, Ixtaccíhuatl, and La Malinche. The parent material ranges in size from very fine ash to pumice particles several centimeters in diameter. The coarser materials are found on the upper slopes of the volcanos and the finer materials near the center of the valley. The *ejecta* has probably been water-reworked over much of the area; some of the ash and pumice, however, have been deposited directly on the land surface during eruptions of the volcanos. The parent materials are distinctly layered due to sorting during these depositional processes.

On the upper slopes of the volcanos the streams are very deep, and the land surface is being continuously eroded away. Little of the eroded material, however, reaches the Atoyac River. Most of the material is deposited as alluvial fan debris. Alluvial fan building is still occurring in the area and is especially noticeable along the San Martín Texmelucan-Huejotzingo highway, where the stream beds are higher than the adjacent land surface.

The external drainage system is well-developed on the upper slopes of the volcanos but is poorly developed toward the center of the valley where alluvial fans are form-

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1. For more information on the climate of the Puebla valley, see Jauregui, E.O. 1968. Mesoclima de la Región Puebla-Tlaxcala. Instituto de Geografía, Universidad Nacional Autónoma de México. México, D.F.

2. The study of the genesis, morphology, and distribution of the soils in the Puebla area was carried out during 1968-1970. Dr. B.L. Allen, soil morphologist, Texas Tech University, Lubbock, Texas, directed and personally conducted much of the field work. He carried out three field studies, each lasting about a week. Dr. Allen contributed most of the ideas and information presented in this section.

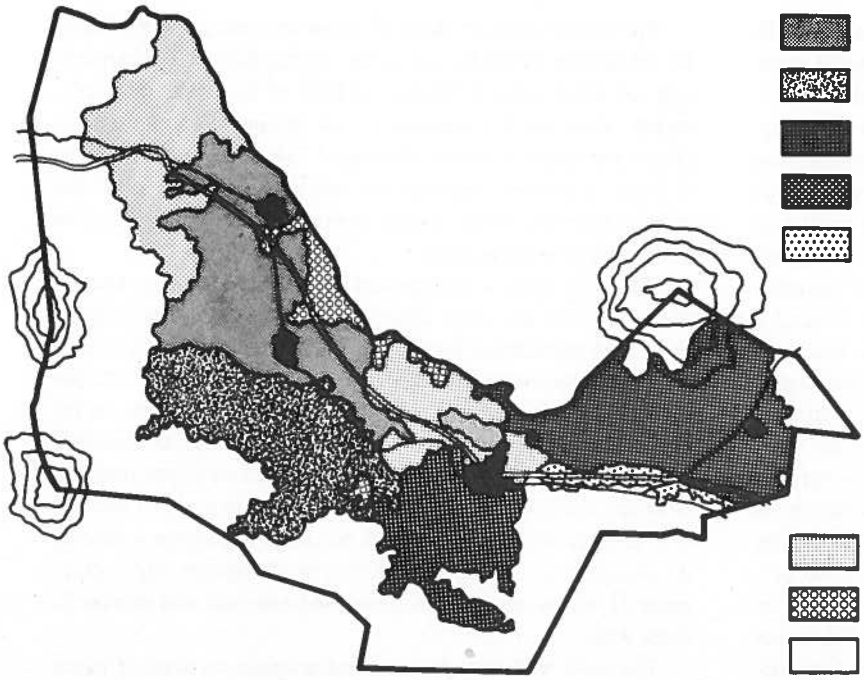

Fig. 1.2. The distribution of the seven most important kinds of soils in the project area. The regions shown in white are largely mountainous with little production of maize.

ing. This has resulted in the formation of soils with a high water table and deficient external drainage on both sides of the Atoyac River. A drainage system consisting of a network of open ditches was constructed in this region many years ago and has been effective in maintaining the water table low enough for the soils to be farmed.

The information accumulated on soils during the early years of the Project permitted the preparation of a soils map (Fig. 1.2) showing the approximate boundaries of the seven most important groups of soils in the Project area. The total area and cultivated area corresponding to each soil group were estimated from aerial photographs and are shown in Table 1.1.

TABLE 1.1. Total area and cultivated area corresponding to seven groups of soils in the Puebla area.

Group	Total area ha	Cultivated area ha
Deeps soils of Popocatépetl	33,618	26,609
Pumiceous soils of Popocatépetl	26,799	19,794
Soils of La Malinche	34,602	25,298
Sodic-like soils	16,560	13,121
Heavy soils of Zone V	3,151	2,700
Soils with compacted horizon	28,912	22,403
Soils with high water table	7,527	6,871
Total	151,169	116,796

The deep soils of Popocatépetl cover an area of about 33,618 ha, of which 26,609 are currently under cultivation. These soils occupy an area extending from the intermediate slopes of Popocatépetl and Ixtaccíhuatl to the soils with a high water table along the Atoyac River. The predominant parent material is a light-brown volcanic ash near neutral in reaction. The texture of the upper 20-40 cm of these soils is loamy sand or sandy loam. This horizon usually contains less than 0.5 percent organic matter, has a pH around 6.5, is high in potassium and calcium, and is fairly high in phosphorus. Underlying this horizon is a layer about 2 m deep with a loam or clay-loam texture that is largely responsible for the high productivity of these soils. This lower horizon has a pH of about 7.0, a cation exchange capacity of around 15 milliequivalents/100 g of soil, and 8 percent of available moisture when wet to the field capacity. These soils, when properly managed, can be planted in April and early May with residual moisture from the previous year.

The pumiceous soils of Popocatépetl cover an area of some 26,799 ha, of which 19,794 are currently under cultivation. The parent material of these soils is largely pumice with some volcanic ash. According to Aeppli and Schoenhals[3], these materials were deposited at the time of the most recent eruptions of Popocatépetl. The stratification observed in most of these soils probably resulted from differences in the materials deposited at different times, not from pedogenic processes.

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3. Aeppli, Hans and Schoenhals, Ernst, 1973. Los suelos de la Cuenca Puebla-Tlaxcala. Comunicaciones 7/1973 Proyecto Puebla-Tlaxcala. Eds. Wilhelm Lauer and Erdmann Gormsen. Fundación Alemana para la Investigación Científica, México. pp. 15-18.

The texture of the upper horizon of the pumiceous soils, which may extend to a depth of 80 cm, is gravelly sand. Despite its coarse texture, this horizon contains about 6 percent available moisture when wet to the field capacity. It usually contains less than 0.5 percent organic matter, has a pH of about 6.5, and a cation exchange capacity of around 6 meq/100 g. The lower horizon may be similar to the corresponding horizon in the deep soils of Popocatépetl or it may be a loose, pumiceous gravel. This latter material has a pH near 7.0, a cation exchange capacity of around 7 meq/100 g, and contains about 6 percent available moisture when wet to the field capacity. When properly managed, the pumiceous soils can be planted with residual moisture.

The soils of La Malinche cover some 34,602 ha with about 25,298 ha under cultivation. These soils have formed from volcanic ash that has been redeposited by water in alluvial fans. The upper layer of these soils, about 30 cm in depth, is usually a sand. This horizon contains 0.5-1.0 percent organic matter, has a pH of around 6.5, is high in phosphorus and potassium, and contains about 7 percent available moisture when wet to the field capacity. A gravelly sand with a depth of a meter or more is usually found underlying this horizon.

Soils with an incipient B horizon are found on the intermediate slopes of La Malinche. This B horizon has a loamy sand to sandy loam texture and a cation exchange capacity of about 15 meq/100 g, with a low base saturation percentage (around 35). On the lower slopes of La Malinche, the lower soil horizon consists of sediments a meter or more in depth, with a sandy loam to silty clay loam texture. These soils are potentially very productive. When properly managed, the soils of La Malinche also can be planted with residual moisture.

The sodic-like soils occupy an area of about 16,560 ha, with 13,121 ha currently under cultivation. The parent material is a light-grey volcanic ash, alkaline in reaction, which is found essentially unaltered at a depth of 60-160 cm, depending upon the degree of weathering of the profile. These soils are similar morphologically to Solonetz soils. The surface or A horizon is a loamy sand about 20 cm deep. This overlies a Bt horizon some 60-100 cm in depth, which is black, contains around 60 percent clay, has a columnar structure, and has a very firm consistency. This horizon is very impermeable and greatly restricts the passage of water and the penetration of maize roots. A thin, greyish-colored A2 horizon showing the effects of reduction processes, is usually distinguishable between the A and Bt horizons.

The Bt horizon has a cation exchange capacity of about 35 meq/100 g, a base saturation percentage of 80, and is slightly alkaline. The content of exchangeable sodium varies from 4-14 percent of the cation exchange capacity; thus, the soils are designated sodic-like rather than sodic. Sufficient moisture to permit early plantings usually cannot be conserved through the winter months. The production potential of these soils is very low under rainfed conditions, but relatively high when irrigation water is available.

The heavy soils of Zone V cover an area of some 3,151 ha, of which 2,700 ha are under cultivation. The morphology of these soils is similar to that of the sodic-like soils, except that the Bt horizon is less developed and the soils thus have better internal drainage. The heavy soils of Zone V have a limited capacity to conserve moisture over the winter months; thus, maize plantings usually can not be made until the rains begin.

The soils with a compacted horizon occupy an area of about 28,912 ha, with 22,403 ha presently under cultivation. The compacted layer that limits both root penetration and water percolation lies at a depth of 20-60 cm from the surface. This layer can be: (a) fragipan, (b) claypan, or (c) *tepetate*. The first two layers are genetic horizons; *tepetate* is a partially consolidated volcanic ash. The surface horizon contains 0.5-1.0 percent organic matter, has a pH of around 6.5, is high in potassium, and contains moderate amounts of phosphorus. Sufficient moisture to permit early plantings of maize cannot be conserved through the winter in these soils.

The soils with a high water table cover an area of some 7,527 ha, of which 6,871 ha are under cultivation. The depth of the water table in these soils varies with their proximity to the Atoyac River, with the seasons, and with the upkeep of the drainage canals. High yields of maize and alfalfa are obtained in soils with the water table more than 50 cm below the surface. These soils are dark-colored loams, high in organic matter, with little profile development. They have pH values around 7.5, cation exchange capacities of about 30 meq/100 g, and contain less than 5 percent exchangeable sodium.

THE FARMING POPULATION

Most of the farmers in the region are descendents of the Indian populations present in the area at the time of the Spanish conquest. In certain villages, Nahuatl, or "Mexican" as it is known in the area, is still spoken, although everyone understands Spanish. The information presented in this section comes mainly from personal interview surveys for 1967 and 1970 (refer to Chapter 8).

Number of Farmers

The number of farm operators in the Project area was estimated to be 43,300. This value was calculated by dividing the total cultivated area, 116,800, by 2.7, the average number of cultivated hectares per farm operator. This latter value is the average of the estimates of the number of cultivated hectares per operator from the 1967 and 1970 surveys.

According to the surveys, the average family consisted of 5.54 members in 1967 and 6.17 members in 1971. Assuming there was no change during the 4-year period in the number of farms in the area, this means the total population included in the families of farm operators was approximately 240,000 in 1967 and 267,000 in 1971.

In addition, there are many families living in the villages who do not operate farm land but depend heavily on agriculture for employment and sustenance. Using 1960 Census data for the 32 *municipios* that comprise the Project area, and the above estimate of the total population of the families of farm operators, there were estimated to be 13,300 landless rural families in the area in 1967.

Size of Holdings

The average farm size, as mentioned earlier, was estimated to be 2.7 ha. The amount of land per farm operator varied considerably as shown below.

Amount of Land Operated	Percentage of Farmers
.50 ha or less	9.2
.51 - 1.00	17.5
1.01 - 1.50	18.7
1.51 - 2.00	10.7
2.01 - 2.50	12.3
2.51 - 3.00	8.4
3.01 - 3.50	4.4
3.51 - 4.00	6.4
4.01 - 5.00	4.4
5.01 - 7.50	4.0
7.51 - 10.00	2.8
10.00 or more	1.2

Type of Land Tenure

The prevalence of different land-holding systems in the area is indicated by the following data from the 1967 survey:

Land Holders	Percent of Farm Operators	Hectares Operated Per Farmer	Percent of Total Area
Ejidatarios	38.2	2.05	31.9
Private holders	27.5	2.74	30.3
Ejido-private	33.5	2.76	37.2
Rented	0.4	3.00	0.5
On shares	0.4	0.20	0.1
	100.0	2.47	100.0

Of special interest is the frequency of combined private and ejidal holdings. *Ejidatarios* are farmers who received land from the government as a result of the agrarian reform. They have the use of the land while they live, but they cannot sell it. Also, private holders value their land very highly and sell only under exceptional circumstances. Consequently, the land market in the area is essentially frozen.

Farmers commonly have several parcels at various locations on different kinds of soils and at varying distances from the farmstead, as shown below.

No. of Parcels per farmer	Percentage of Farmers
1	16.7
2 or 3	52.5
4 or 5	21.2
6 or 7	5.6
8 or 9	4.0
10 or more	0.0

The average farm size in the project area is about 2.7 ha. Approximately 90% of the farms have 5 ha. or less.

At certain peak labor periods, such as planting and harvest, the whole family helps in the field and additional workers may be hired. As the fields are often far from the village, the women usually bring the noon day meal.

This phenomenon is explained in part by the farmers' awareness of land quality. To be fair to all when the ejidos were organized, the farmers frequently decided that each ejidatario should have a piece of each of the two or three qualities of land, instead of a single block of land. A similar procedure is often followed by private owners in leaving land to their children.

The Family and the Home

The family provides both the management of the resources used in agricultural production and most of the labor used on the farm. Where labor is hired, it is usually for short periods of peak activity, such as at harvest time when there may, in fact, be a shortage of labor in the region. Much of this hired labor is offset by members of the family working off the farm at other periods when labor needs on the farm are low.

About 77 percent of the farm operators have some ability to read and write, as shown in the following data from the 1967 survey.

Schooling	Percent of Farm Operators
Never attended school:	
Illiterate	22.7
Self-taught, literate	4.3
Attended school for:	
1 year	10.0
2 years	17.1
3 years	22.3
4 years	9.6
5 years	4.4
6 years	8.0
More than 6 years	1.6
Average years of schooling:	
All farmers	2.4
Farmers who attended school	3.2

The impression is that at least half of those with some degree of literacy read and write with considerably difficulty. The percentage of farmers with 3 years or more of schooling, 45.9, is perhaps a reasonable estimate of those that are functionally literate.

It is customary in the area for farmers to live together in villages. Homes are usually (76 percent) made of sun-baked adobe bricks. The floors are frequently of brick, cement, or tile, but 36 percent are of dirt. The dwellings are small as indicated in the next table (1967 survey).

Rooms (other than Kitchen) in the Farm Home	Percent
One which is also the kitchen	1.2
One room	43.8
Two rooms	32.3
Three rooms	14.7
Four rooms	5.2
Five or more rooms	2.8

Though most of these families live humbly, many have some of the minimum comforts associated with modern living as can be seen in the following table (1967 survey).

Living Comforts	Percent
Have electric lights	62.9
Have radio	59.8
Have a sewing machine	45.0
Cook with gas, electricity, or fuel oil	28.7
Have piped water in home or street	13.1
Have television	8.0
Have drainage	6.0
Have refrigerator	1.6

In nearly every case, the family diet depends heavily on home produced food. The poorest families eat practically nothing besides maize and beans with small quantities of chiles, onions, and tomatoes for seasoning. Those with more resources occasionally consume wheat bread, eggs, and meat, and their children drink milk.

The average total family income, estimated from the information provided by the 251 farmers in the 1967 survey, was $666.80. As is shown below, the income came from four main sources:

Sources of Family Income	Percent
Net income from crops	30.4
Net income from animals	28.4
Off-farm wage income	23.7
Other non-farm income	17.0

Although most of the family income was derived from farming activities, there was some non-farm income, mainly from domestic, commercial, and industrial employment in nearby cities.

Contact with Ideas from Outside the Community

There exists an excellent opportunity for contact with the large urban society outside the villages. Local roads are rough and eroded, but in most cases they are passable during the entire year. The local buses are battered with years of wear, but provide a regular and inexpensive means of transportation for both people and produce. Traveling outside the village, however, is not undertaken casually. According to the 1967 survey, only 24 percent of the farmers leave the village at least once a week. Another 14 percent leave every 2 weeks or every month, 43 percent rarely leave the village, and the remaining 19 percent reported that they never leave the village.

In spite of limited physical mobility, there is contact with ideas from outside the villages, principally through radio, as suggested by the following data from the 1967 survey.

	Percent of farmers
Have a radio	59.8
Listen to it daily	50.2
Listen to a farm program	21.9
Have a television set	7.9
See TV at home or elsewhere at least once per week	12.4
Read farm magazines regularly	1.6
Read newspapers regularly	7.9

LOCAL PRODUCTION TECHNOLOGY

The percentages of the cultivated land used for different crops were estimated from survey data for 1967 and 1970:

Crop	Percent of Cultivated Area
Maize	69.4
Beans	15.9
Alfalfa	5.3
Vegetable crops	3.0
Fruit trees	0.9
Others	5.5

Most of the maize, beans, and fruit trees are produced under rainfed conditions. Alfalfa and vegetable crops usually receive supplementary irrigation.

The important cropping systems under rainfed conditions in the Puebla area are: (a) maize alone, (b) the maize-pole bean *(Phaseolus vulgaris)* association, (c) bush beans *(Phaseolus vulgaris)* alone, (d) maize interplanted in orchards, and (e) scarlet runner beans *(Phaseolus coccineus)*, known locally as *ayocote*. Pumpkin (*Cucurbita* spp.) is interplanted in many of the maize fields with a population density of 300-1,000 plants/ha.

Maize planted alone is the most important crop in the Project area. The maize-bean association is the second most important cropping system in Zones I, II, and IV (see Fig. 1.2). Bush beans is the second most important crop in Zone III. Bush beans and *ayocote* follow maize in importance in Zone V, yet occupy a small fraction of the total area. Bush beans is the third most important crop in Zones I, II, and IV. Maize interplanted in orchards is most common in Zone II.

The staple food of the rural families in the Puebla area, as in the rest of Mexico, is maize. It is eaten mainly in the form of a thin bread or *tortilla*. The average annual consumption of maize per person in the Puebla area is about 250 kilos.

The local production technology for these crops is the product of centuries of interaction among the farmers, their environment, and external influences. There is solid evidence that primitive wild maize was domesticated as long as 7,000 years ago in the highland region of which the Project area is a part. When the Spanish conquerors arrived at Cholula (near the center of the Project area) they found the inhabitants cultivating maize. The historian Bernal Díaz del Castillo reports that the farmers in the valley of Mexico at the time of the conquest were using human excrement and fish bones to fertilize maize. It is probable that knowledge of these practices extended to the nearby Puebla valley.

Genetic Resources

Great phenotypical diversity is evident in the local varieties of maize, bush beans, pole beans, and pumpkin. Most of the local maize varieties belong to the Chalqueño race. For early plantings in March and April, farmers use late-maturing varieties that flower in 100-120 days and require about 180 days to reach physiological maturity. These early plantings usually experience some moisture stress during the first 2 or 3 months, but have adequate moisture during the rest of the growing season. The late varieties are generally high-yielding; yields of 10 ton/ha of grain have been reported in field trials.

Farmers use early-maturing varieties with a biological cycle of about 130 days for late plantings in June. These varieties flower in 75-90 days after planting. Typical environmental conditions during the early growth stages of late plantings are cool temperatures, low light intensities, and abundant moisture. The yielding potential of early varieties is only about half that of late varieties.

In addition to this relationship between earliness and yielding potential, the length of the growing cycle of maize varieties tends to be correlated with the height of the plants, shape, texture, and color of the grain, and (probably) tolerance to early drought. Late-maturing varieties are about 3 meters tall and have grain that is usually dented, hard, and light-colored. Early-maturing varieties are about 2 meters tall and produce large kernels that are usually floury and dark-colored (red or blue).

Maize varieties with an intermediate growing season also are available in the area for May plantings. Most native varieties are susceptible to lodging when produced under favorable growing conditions.

Data collected in the 1967 survey indicated that 54.6 percent of the farmers knew about hybrid varieties of maize. About 15 percent of the farmers had planted hybrid maize on at least one occasion, but only 0.8 percent of them planted a hybrid in 1967. Of the farmers who knew of hybrid maize but had never planted it, 64.2 percent gave as their reason that hybrids did not outyield their local varieties, or did so only under irrigation.

The length of the growing season of beans tends to be correlated with the growth habit and the size, form, color, and flavor of the grain. Beans with a long growing season have an indeterminate growth habit (pole beans), large grains, light colors, and a flavor preferred by most consumers. Beans with a shorter growing cycle have a determinate growth habit (bush beans), smaller grain, and a less popular flavor. (The yielding potential of the maize-pole bean association is suggested by the results from a later field trial in which the association receiving both chemical fertilizers and chicken manure produced 4.5 tons of maize and 3.0 tons of beans per hectare).

Little is known at present about local production technology for *ayocote* and pumpkin. The experimental study of the maize-pumpkin association was not undertaken until 1973.

Production Practices

Most farmers manage their soils so that moisture present in the profile at harvest time is conserved through the winter months; thus maize can be planted in March and April, some 2 months before the rainy season begins. Farmers cut and shock their maize as soon as it reaches physiological maturity; they then plow immediately and smooth the surface with a wooden plank. This operation is usually done in October and repeated in February or March. Maize planted in these soils with residual moisture usually suffers from drought before the summer rains begin. This moisture stress slows down or stops vegetative growth, but other physiological processes continue. As soon as the rains begin, the maize continues its vegetative development. If drought is not too prolonged, the maize has sufficient time to produce large plants and a good yield. By preparing their land in this manner, farmers (under rainfed conditions) are able to use late varieties that require 180 days to reach maturity in an area where the period with rainfall and without critical frosts lasts only 140 days.

Farmers who plant with residual moisture understand that agronomic risk in their plantings is due primarily to drought during the period between planting and the beginning of the rainy season and to the midsummer or intraestival drought (usually between July 15 and August 15). Those who plant early are betting that drought during the period before the rains begin will not be severe; they stand to gain a high yield if early drought is slight. Farmers who plant late are betting that early drought will be severe; they stand to gain yields less than those produced by early plantings if early drought is slight—but will produce comparatively higher yields if early drought is severe. Thus, planting date is a variable that can be manipulated. The usual practice is for farmers to use a mixed strategy in choosing the date of planting; that is, they distribute early plantings over a period of a month or so.

Present technology does not provide for the conservation of sufficient moisture during the winter months to permit early plantings of maize in sodic-like soils, heavy soils of Zone V, and soils with a compacted horizon. These three groups of soils occupy 33 percent of the cultivated land in the Project area (Table 1.1.). In addition, some of the farmers with soils capable of retaining sufficient moisture for early plantings are unable to plant early because they do not employ moisture conservation practices at the proper time. Furthermore, it is usually not possible to conserve sufficient moisture to permit early maize plantings in soils where maize is interplanted in orchards. These three categories account for a sizeable area that is not planted until the rains begin. Farmers use short-season varieties for these late plantings. In the rare years when rains do not begin until early July, farmers prefer not to plant maize because of the frost hazard. According to 1967 survey data, maize plantings for that year were spread over a three month period, as shown below.

Date of Planting	Percentage of Land
Before March 1	3.8
March 1-31	34.6
April 1-30	37.4
May 1-31	17.8
After May 31	6.4

In their plantings of maize alone or in association, farmers use between 15,000 and 35,000 plants/ha, depending upon the fetility level of the soil and the amount of fertilizer to be used. If pole beans are grown with maize, the farmers sow sufficient seed on the same date to give a bean density of 5,000-20,000 plants/ha. A common rule-of-thumb is one bean plant for every two plants of maize. Maize plants that have no adjoining bean plant help support the weight of the beans and prevent lodging. The distance between rows of maize is about 90 cm.

Farmers use two methods for planting and cultivating bush beans: (a) planted in rows 70 cm apart and cultivated with animal-drawn implements, and (b) planted in rows 50 cm apart, using the method called *a barbecho*. In this method, the soil is turned with a single-moldboard plow, the seed is deposited at the bottom of the furrow, and then it is covered by the following passage of the plow. Cultivations are made with a hoe. Population densities are about 60,000/ha for the first method; 90,000/ha for the *a barbecho* method. The *a barbecho* method is commonly used in soils with a high content of pumice in the plow layer, possibly because of the ease of hand weeding.

According to the 1967 survey data, 95.2 percent of the farmers in the Project area knew of chemical fertilizer; 80.1 percent had used it on at least one occasion; and 69.3 percent had used it in 1967. These farmers in 1967 used an average of 49.3 kg/ha N and 20.3 kg/ha P_2O_5. For the entire cultivated area in 1967, the average amounts were 34 kg/ha N and 14 kg/ha P_2O_5. Of the farmers applying fertilizers in 1967, 64 percent used the formula 10-8-4, 18 percent used ammonium nitrate or ammonium sulfate, and 15 percent used other formulas.

Chemical fertilizers have been used for several years in the Puebla area as indicated in the survey data shown next.

In What Year Did You First Use Chemical Fertilizers?	Percentage of Farmers
Have never used it	19.9
1967	7.5
1966	7.5
1965	10.4
1964	6.4
1963	6.4
1962	6.0
1961	2.0
1960	6.8
1959 or before	27.1

When the Project began in 1967, 95% of the farmers knew of chemical fertilizer and 80% of them had used it at least on one occasion. Most felt that some fertilizer was needed, but did not know which elements or how much to apply.

Of the 251 farmers interviewed in 1967, 191 provided information on time of applying fertilizers to maize as shown next. Most farmers applied fertilizer only once, at the time of the first cultivation.

Time of Fertilizer Application	Percentage of Farmers
At planting	2.6
At first cultivation	63.4
At second cultivation	24.1
At both 1st. and 2nd cultivations	9.9

Maize planted alone or in association is usually cultivated twice: the first cultivation 30-40 days after planting, and the second cultivation 60-70 days after planting. Farmers take into account the amount of soil moisture, probability of frost, and size of the weeds, in deciding when to make the first cultivation in early plantings of maize using residual moisture. Cultivating is postponed if a frost is thought likely. The second cultivation is made after the maize is 60 days old and when the soil is moist to a depth of at least 30 cm. Some weeds are allowed to grow in the maize and are harvested for forage as needed.

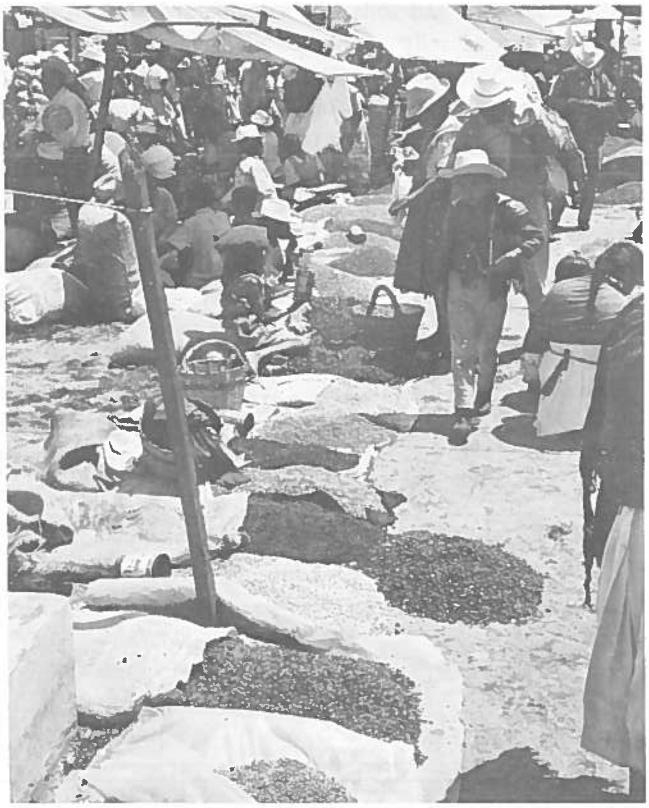
Farmers in Zone III practice a 2-year rotation of maize and bush beans. Chicken manure (5-10 tons/ha) is applied to the maize immediately before the first cultivation. Bush beans are then grown the following year without fertilization. Yields of both maize and beans are relatively high using this rotation.

It is a common practice in Zones I and V (and to a lesser extent in the rest of the area) for farmers to top the maize plants when the grain is still in the milk stage and to cure the tops in the field and preserve them as high-quality forage. The rest of the plant is cut and shocked as soon as the grain reaches physiological maturity. Later, the ear is harvested and the rest of the plant is preserved as forage of a poorer quality than that of the tops.

Farmers use few insecticides and herbicides. Forty-one percent of the farmers in 1967 knew of chemical insecticides and 22 percent had used them on some occasion, principally to control insects on beans.

AGRICULTURAL SERVICE AGENCIES

Two official credit banks, the National Agricultural Credit Bank and the National Ejidal Credit Bank, were operating in Puebla in 1967. According to survey data, 6.4 percent of the farmers received credit from the Ejidal Bank that year and 0.4 percent from the Agricultural Bank. Another 5.2 percent of the farmers obtained credit from other sources, mainly private lenders. A third official bank, the National Crop and Animal Production Bank, established a branch in Puebla in 1967.



Only 39% of the farmers sold maize in 1967. Most of this maize was sold to local buyers who picked it up at the farm home, or it was retailed in the village on market days. The maize was marketed throughout the year, to cover various costs, especially medical care.

Crop production inputs–fertilizers, improved seeds, insecticides, herbicides, etc.–were available to farmers in 1967 through merchants in the principal cities of Puebla, San Martín Texmelucan, Huejotzingo, and Cholula. In addition, there were 42 villages in which a total of 80 store keepers bought fertilizer and resold it at the local level.

According to survey data, only 38.8 percent of the farmers sold maize in 1967. This maize was marketed throughout the year, mainly to cover the costs of medical care. About 30 percent of the maize was purchased by the National Marketing Agency, CONASUPO, at the support price of $75.20/ton. The remainder of the maize was sold to local buyers at the official price or slightly less.

A branch of the National Agricultural Insurance Agency operated in Puebla in 1967 and provided crop insurance to farmers receiving credit from the official banks. An agency of the National Agricultural Extension Service was located in the city of Puebla, with one extension agent in San Martín Texmelucan. There was no agricultural experiment station, but investigators of the National Agricultural Research Institute occasionally conducted field trials in the Project area.

The characteristics of the service agencies, their activities during 1967-1973, and factors limiting their effectiveness are discussed in Chapter 7.

2 PROJECT OPERATIONS AND COORDINATION: AN OVERVIEW

INTRODUCTION

The Project area was selected in early 1967 after evaluating information collected in visits to the area just prior to the maize harvest in 1966, reviewing the results from earlier experiments, and studying weather data from several locations in the region. Members of the CIMMYT staff played a key role in the initial planning and setting up of operations. Financial support for the Project was approved in March, 1967, and a research agronomist and a maize breeder were employed soon afterwards. The first field experiment was installed on April 18, 1967.

This chapter is designed to highlight program operations as they evolved from 1967 to 1973, and to briefly describe the coordinating and staffing functions.

EVOLUTION OF THE PROJECT

Several agricultural service agencies were operating in the Puebla area when the Project was organized, as indicated in Chapter 1. The role of the Puebla Project, as conceptualized by its planners, was to complement the activities of these existing agencies by (a) providing those services that were lacking, and (b) coordinating the total effort to assure adequate and accessible agricultural services for the small farmer.

Project Operations: 1967

The information available in early 1967 indicated that maize yields would be greatly increased by applying adequate quantities of nitrogen and phosphorus, using higher plant densities, and controlling weeds properly. Thus, the emphasis in the first year was on agronomic research to identify outstanding maize varieties and to determine optimal packages of production practices. The program to provide technical assistance to farmers was postponed until reliable recommendations on maize production practices were available.

Although the search for a Project coordinator was begun in March 1967, four months elapsed before a qualified person was found for the position (detailed discussion of the coordinator's role is reserved for following section). On joining the Project in August 1967, the coordinator carried out a general reconnaissance of the area, traveling over most of the all-weather roads, and observing the technology used by the farmers in maize production. Farmers were questioned about their production practices, average yields, relationships with agricultural institutions, and possible interest in participating in the Project.

This exploration led to a better understanding of the nature of the problem of increasing maize production in the Project area. It brought clearly into focus the need for a formal survey to gather more detailed information on the characteristics of the farmer and his family, the production technology in use at the time, farmers' attitudes toward change, etc. As a result, the decision was made to add socioeconomic evaluation as another component of the Project. An evaluation specialist was selected in late 1967, and the first personal interview survey of the farmers was made in January and February of 1968.

Concurrent with the study of the Project area and the farming population, the coordinator proceeded to consolidate relationships with the agricultural institutions in Puebla. Interviews were held with the leaders of the different institutions, and they were informed about the philosophy, objectives, organization, and operation of the Project. Discussion in these interviews emphasized the importance of the role of each institution in achieving the goals of the Project.

The interviews also allowed the coordinator to become familiar with all national, state, and local institutions, as well as private organizations, involved in agricultural development in the area. A study was made of the objectives, organization, and operating procedures of each institution, and an understanding was sought of the decision-making process and the responsibilities of key individuals of the different organizations. This knowledge was helpful in deciding how to proceed in seeking a solution to particular problems.

The fertilizer and maize breeding experiments were harvested as soon as the maize reached maturity. Then the results were analyzed and a general recommendation was formulated for producing maize in the area. This recommendation called for a fertilizer treatment of 130-40-0, a plant density of 50,000/ha, early control of weeds, chemical control of high infestations of rose chafer at flowering, and the use of native maize varieties.

The first Annual Meeting of the Puebla Project was held at Puebla in December 1967. Representatives of all agricultural institutions were invited, and the Project staff explained the experimental findings and the maize recommendation for 1968.

Project Operations: 1968

The package of recommended practices for 1968 implied three principal changes for the agricultural institutions: (a) an increase in the amount of credit per hectare needed to purchase fertilizers, (b) substitution of ammonium sulphate

At the end of each season, after results had been evaluated, meetings were held at which the members of the Project team presented their findings and recommendations to representatives of the agricultural service institutions.

and ordinary superphosphate for the formula, 10-8-4, and (c) availability of the credit and fertilizer materials at the local level in March rather than in May.

The changes implied by the new recommendation were discussed individually with representatives of the different institutions. In general, it was found that the institutions accepted the findings of the Project, but were uncertain as to their participation. The three official banks were reluctant to introduce changes of the suggested magnitude until their value had been demonstrated in a network of commercial plantings. The banks felt their credit programs to farmers were satisfactory. In their view, the changes recommended by the Project would present additional risks because of the larger amounts of credit required, as well as a possible loss of prestige should the new technology not provide good results.

The crop insurance agency maintained that, after the new recommendation had been accepted by the credit banks and their clients, the farms using the recommendations could qualify for insurance. This agency, however, had rigid operating procedures that did not permit coverage for individual small farmers. Again, change was necessary if the crop insurance agency were to participate; these changes required the presentation of proposals to higher authorities and favorable action at that level.

The Project plans drafted in early 1968 called for a continuation of research on maize improvement and agronomic practices, and the initiation of the program of technical assistance to farmers. The assistance program was to consist of approximately 100 "high-yield" plots of 0.25-1.0 ha. The farmers owning these plots would use Project recommendations, and they would be supervised by a technical assistance agent who had been added to the Project staff in early 1968. The experiments and high-yield plots were limited to the western two-thirds of the Project area (known later as Zones I through IV) in order to concentrate the efforts of the available staff.

The cost of the fertilizer for the high-yield plots could have been considered a demonstration cost and paid by the Project. However, because the plots of 0.25-1.0 ha represented a large portion of the total area in maize of many farmers, it was decided that free provision of fertilizer would establish a difficult precedent. Also, procedures for obtaining credit required immediate testing, to facilitate channeling of credit and fertilizers to more farmers in the area.

Two of the official credit banks decided not to provide credit for the high-yield plots in 1968. The third official bank agreed to finance about 20 percent of the high-yield plots. Another 20 percent of the plantings were financed by the farmers. The remaining 60 percent were financed by a private fertilizer distributor, Agrónomos Unidos, which made the fertilizer available on credit at an interest rate of $1\frac{1}{2}$ percent/month (these loans were quaranteed by CIMMYT). A total of 141 plots were provided for, far in excess of the 100 plots originally planned.

Field personnel of the credit banks provided suggestions for locating farmers to cooperate in the Project in 1967 and early 1968. In conducting the socioeconomic survey in early 1968, however, the evaluation team encountered negative reaction, and sometimes open hostility, from the farmers in several villages. This experience, plus other observations in the area, strongly indicated that contact should be made directly with the local authorities of each community. The coordinator proceeded to establish contact with each village in the area and to hold meetings to explain the objectives and operation of the Project and assess the interest of the farmers.

The experimental plantings and the high-yield plots were used as demonstrations of the importance of the improved production practices from the time the maize began to flower until harvest. Throughout this period, field days were held for representatives of the agricultural institutions and for groups of farmers. The field days for institutions had two principal objectives: (a) to convince the leaders of the institutions that recommendations, based on the field experiments, represented the most reliable information available for increasing yields, and (b) to acquaint these leaders with the capability of the Project staff. The field days for farmers sought to demonstrate the results they could expect through use of the recommended practices.

During 1968, audio-visual materials were prepared, using the results obtained in 1967 and the experimental plantings and high-yield plots. These were prepared specifically for use in reaching large numbers of farmers in subsequent years.

Just prior to harvest in 1968, the evaluation specialist determined grain yields of the high-yield plots and of a sample of farmers' plantings. Experimental plantings were harvested in October and November, the data were analyzed, and new maize recommendations were proposed. The Second Annual Meeting was held in December 1968, to inform representatives of the agricultural institutions of the accomplishments during the year.

By the end of 1968, several findings were clear: (a) large increases in maize yields could be obtained throughout the Project area; (b) after seeing the results of agronomic research, the technical assistance to farmers, and the evaluations, representatives of the agricultural institutions were convinced of the value of Project recommendations; (c) the farmers who had cooperated with a part of their land in high-yield plots were prepared to assist other farmers in using the new technology; and (d) the Project staff, farmers, and agricultural agencies could be effectively coordinated in working to achieve the goals of the Project.

Project Operations: 1969

Plans for 1969 called for three major modifications in the operation of the Project: (a) research activities would be extended to cover the entire area; (b) the western three-fourths of the area would be divided into four zones (see Fig. 1.2), and a technical assistance agent would be assigned to each zone; and (c) a coordinated effort would be made to enlist 5,000 farmers to use Project recommendations on 10,000 ha of maize.

The decision to promote the use of Project recommendations so extensively in 1969 was made after careful study and discussion by the Project staff and state representatives of national agricultural institutions. Expansion of the program to reach 10,000 ha of maize would require credit needed for fertilizer alone amounting to about $560,000. Discussions with the different institutions led to the proposal that the National Ejidal Credit Bank would finance 2,000 ha, the National Agricultural Credit Bank 1,500 ha, the Agricultural Bank of the South 1,500 ha, and that the Impulsora de Puebla, through its subdistributor, Agrónomos Unidos, would finance 5,000 ha. This proposal was approved at the national level.

The plan to reach 5,000 farmers in 1969 implied a drastic change in operating procedures of the technical assistance agents. In 1968, one technical assistance agent, assisted by the evaluation specialist, had given individual attention to 103 farmers. In 1969, four agents would have to assist up to 5,000 farmers. Such assistance seemed possible only if the farmers organized into groups.

The four technical assistance agents launched a program to inform the farmers in the area about the maize recommendations, and to assist them in organizing into groups and arranging for credit and fertilizers. The field personnel of the credit banks, the National Marketing Agency, and the crop insurance agency, assisted in this work. In their relationships with the farmers, the technical assistance agents made sure that arrangements for credit and fertilizers were always made between the credit institutions and the leaders of the farmer groups. Thus, the responsiblity for procuring credit and fertilizers remained with the individual farmer or the group leader.

During the cropping season, field days were held for farmers and representatives of the agricultural institutions. Here the Minister of Agriculture, the Governor of Puebla and other dignitaries listen to an explanation of the agronomic research program.

Perhaps the most crucial period in the development of the Project was in early 1969. Although the specific functions of the Project staff and participating institutions were defined well in advance of planting, the task remained of coordinating all activities so that the farmers would have fertilizers when needed. The correct fertilizer materials had to be ordered early, freight cars had to be available to transport the material to Puebla, the shipments had to be received by the distributors and dispatched to subdistributors, and the farmers had to arrange for credit so they could pick up their fertilizers when needed. Problems developed at all points in this chain of events, and continuous contact by the coordinator and a clear understanding of the operation of each institution provided the means to reduce delays to a minimum and to avoid the loss of prospective cooperators.

A total of 2,561 farmers, organized in 128 groups, were assisted in using Project recommendations on 5,838 ha. Although the total fell short of the stated goal for 1969, some 5.4 percent of the farmers in the area did begin using the new technology that year.

During the fall of 1969, regional demonstrations were held at six locations in the area. The average maize yields of organized farmers and all farmers in the area were estimated, agronomic trials were harvested, and the maize recommendations were refined. The Third Annual Meeting was held in early January 1970, attended by political leaders, representatives of agricultural institutions, farmers, and Project staff.

Project Operations: 1970

A principal addition to the Project in 1970 was the initiation of technical assistance to farmers in Zone V (Fig. 1.2). A fifth technical assistance agent was assigned to this zone.

The main thrust of the technical assistance program in 1970 was to increase the use of Project recommendations by (a) informing farmers of the new technology through village meetings and mass communications media, and (b) assisting in the formation of new groups and in helping organized farmers arrange for credit and fertilizers. A special effort was made to increase the participation of the public credit banks by counseling new groups to seek financing from these sources, and by assisting the groups in making the necessary arrangements.

The agronomic research program was expanded in 1970 to include studies on the production of beans and alternative crops for late plantings. The investigations of the production of these crops were made in response to requests from many of the farmer groups that had used the maize recommendations the previous year.

In early 1970, CIMMYT signed an agreement with the United Nations Development Program that led to the participation of the Puebla Project and its advisors in the development of similar programs in other areas (refer to Chapter 13). The Project and its advisors participated mainly in two activities: (a) the training of professional staff for new programs in the philosophy, organization, and operation of the Puebla Project (refer to Chapter 12); and (b) technical assistance to the staff of new programs in organization and agronomic research. A group of technicians from Colombia and Mexico were in training in Puebla during the second half of 1970. Project advisors traveled to Colombia and Peru on several occasions during the year to assist in planning and organizing programs in those countries.

Project staff and advisors participated in two international conferences held in Puebla in August 1970, to discuss strategies for increasing agricultural production on small holdings. These conferences (English spoken at one, Spanish at the other) drew participants from 15 Latin American countries and 15 international development organizations.

Demonstrations at harvest time, estimations of yield, and adjustment of maize recommendations were conducted as in previous years. In addition, recommendations for the production of bush beans were formulated for parts of the Project area. The Fourth Annual Meeting was held in mid-February 1971.

Project Operations: 1971

The operation of the Project in 1971 was similar to 1970, with one principal difference: a second personal interview survey was conducted during the summer of 1971 to collect data for evaluating social and economic changes in the Project area. Interviews were made of a sample of all farmers in the area and a second sample of those farmers on credit lists.

The technical assistance agents broadened their activities in response to the requests from the farmers for assistance in improving other agricultural activities. Short courses for farmers on the management of orchards were given, with the participation of specialists from other institutions. Demonstrations were held to instruct farmers in the use of small trench silos for preserving maize stover as silage. Several groups were assisted in arranging for long-term loans to finance the drilling of wells, or for purchase of farm machinery.

Technicians from Colombia, Ecuador, Peru, and Mexico were trained in Puebla during 1971. Project staff and advisors provided technical assistance to regional production programs in Colombia, Peru, Honduras, and the States of Mexico and Tlaxcala in Mexico.

The Fifth Annual Meeting was held in Puebla in mid-February 1972.

Project Operations: 1972

In early 1972, the maize breeding component of the Puebla Project was discontinued. Progress in developing higher-yielding varieties had been slow (refer to Chapter 4). Moreover, the maize breeders in CIMMYT felt that this type of research could best be done at a research center with ecological conditions similar to the Project area. Varietal testing continued and became a part of the agronomic research program.

Results obtained in preliminary studies of the maize-pole bean association in 1970 and 1971 indicated that net income might be greater with the combination of crops than with either maize or bush beans alone. Research was intensified on management practices for this association, to develop recommendations for its use.

The effort to achieve a closer coordination of the activities of the farmers, agricultural institutions, and Project staff in previous years had disclosed problems that required changes in the operating procedures of institutions. At times, through a careful exposition of the problem to the indicated institution, it had been possible to reach a satisfactory solution. In other cases, however, little or no progress had been made. It became clear from these experiences that a more detailed study was needed of the operating procedures of the agricultural institutions and of the reasons farmers have difficulty in using their services. Such a study was undertaken in mid-1972.

Another increasing concern of the Project staff was how to develop the capacity of the farmer organizations to participate more actively in seeking solutions to their production problems. In mid-1972, arrangements were made to contract the services of a sociologist with years of experience with farmer organizations, who would provide technical assistance to the Project staff in searching for a more effective way of working with the farmer groups.

CIMMYT decided in early 1972 to terminate its participation in the Puebla Project at the end of 1973. The Project had begun in 1967 as an experiment to learn how to rapidly increase maize production among small, low-income farmers. As the Project evolved, however, it became clear that the Project's objectives would shift to more efficient strategies for increasing production, net income, and the general welfare of small farmers in rainfed areas. CIMMYT felt that its mandate was not broad enough to encompass all the activities that clearly should be incorporated in so extensive an undertaking. This position was made known to the Governor of Puebla and the Secretary of Agriculture, making clear CIMMYT's reasons for withdrawing support, as well as the conviction that the Project should continue.

A seminar on rural development was held in Bogota, Colombia, in September 1972, with the participation of representatives of the Puebla Project and similar programs in Colombia, Honduras, Peru, and Mexico. The International Development Research Center (IDRC) of Canada took the initiative in organizing the seminar and provided financial support.

The Sixth Annual Meeting was held in Puebla in March 1973.

Project Operations: 1973

The program of technical assistance to farmers was broadened in 1973 to include promotion of the use of: (a) a new technology for the maize-pole bean association, and (b) agua ammonia as a source of nitrogen for maize. The national fertilizer agency, Guanos y Fertilizantes, introduced the idea of finding a way to enable small, traditional farmers to use agua ammonia. The agency provided the agua ammonia, a source of phosphorus, applicators, credit, and technical assistance. The Project technical assistance agents informed the farmers of the availability of credit for these fertilizers and assisted interested farmers in organizing and in arranging for and applying the materials.

During the second half of 1973, the technical assistance agents, after months of discussions about how to work more effectively with farmer organizations, began to work more intensively with selected groups. A series of meetings was held in which the farmers and the technical assistance agent explored operations that could increase net income of the farmers. From these discussions, it could usually be agreed that one activity should be given priority. A committee was elected by the farmers to study how to proceed on the priority undertaking. The technical assistance agent provided information and guidance to these groups, but responsibility for group action remained with the farmers.

A second seminar on rural development, with financial support from IDRC, was held at Chapingo, Mexico, in September 1973. The staff and advisors of the Puebla Project participated in the organization of the seminar and in the conferences and work sessions.

In early 1973, the Project staff and advisors began to explore, with political leaders of the state and federal governments, means for continuing the Puebla Project after CIMMYT had terminated its participation. Discussions and study at several levels proceeded during the year, and shortly before the end of 1973, the Ministry of Agriculture decided to continue the Project as an activity of the Graduate College at Chapingo. Present expectations are that the Project will become a part of a new national program to increase agricultural production in rainfed areas of the country.

COORDINATION

The coordinator has been the central figure in the operation of the Puebla Project. His function has been that of coordinating activities of the farmers, agricultural institutions, and Project staff so as to enable small farmers to attain higher levels of production and net income. In practice, his responsibilities have included three distinct (but closely related) activities: (a) administration of the program, (b) direction of the program, and (c) acquisition and maintenance of the full support of the agricultural institutions.

The Project coordinator made most of the decisions affecting the administration of the Project. He was responsible for locating candidates for staff positions, evaluating their qualifications, and deciding whom should be hired. He recommended salary levels and perquisites for Project staff, the purchase of vehicles and equipment, budget changes, etc. He approved the local expenditure of funds for day laborers, supplies, gasoline, vehicle maintenance, etc.

The coordinator directed the activities of the Project staff in the: (a) preparation of operational plans, (b) execution of these plans, and (c) the summarizing and reporting of accomplishments. Each program presented its plans for the year at meetings of staff and advisors that were generally held in January. The plans were discussed, modified and finally approved. Weekly meetings were held throughout the year to discuss progress and problems of the staff. Adjustments in operational plans, as a result of new information, were made at these meetings. Important matters affecting the operation of the Project were discussed fully at the weekly meetings before a decision was made by the coordinator. The coordinator maintained contact with the field work by accompanying the members of the staff, as time permitted, in their daily activities. At the end of the year, the coordinator worked with the staff members in analyzing, evaluating, and reporting the results of their programs.

A large part of the coordinator's time was dedicated to work with the agricultural institutions. Initially he was involved in informing the institutions of the philosophy, objectives, and plans of the Project, and becoming familiar with their operating procedures. Then, as information flowed in from the field work, much of this data had to be communicated to the institutions. For 2 or 3 months after harvest, the coordinator was in almost constant contact with representatives of the institutions, explaining the plan of operations for the following season and working to obtain their approval and support. When a problem arose due to the operating procedures of an institution, information about the problem was prepared by the Project staff and communicated by the coordinator to the responsible people. Generally this was followed by a series or meetings and the gathering of additional data until a decision could be made.

PROJECT PERSONNEL

From the beginning it was recognized that the quality of the Project staff would be the most important factor in assuring the success of the undertaking. Screening procedures were followed which, hopefully, would assure the selection of the best candidates available.

The Project sought to provide working conditions and opportunities that would enable its staff to work harmoniously and effectively and to advance professionally through (a) salaries and perquisites that were competitive with other employment opportunities; (b) opportune availability of the necessities for getting the job done (adequate operating expenses for vehicles, prompt purchase of equipment and supplies, revolving funds for the purchase of small items, prompt repair of vehicles and equipment, etc.); (c) encouragement to use initiative and be innovative (the staff could not be provided with an operations manual that would cover every exigency that might arise; thus, the team members were encouraged to work out their own solutions when confronted with new problems and to seek advice from other staff and advisors as soon thereafter as possible); and (d) opportunities for advancement (outstanding team members were given the opportunity to advance both in salary and in professional position; also, staff members interested in continuing their academic preparation were assisted in doing so, after 2 to 3 years with the Project).

Because of the Project policy encouraging its staff members to continue their academic training, plus the availability of other job opportunities, especially in regional production programs in other parts of Mexico, there were frequent changes in Project personnel. Figure 2.1 shows diagrammatically the periods of employment of professional staff during the period 1967-1973. The shortest period of service was one cropping season; the longest service was 6 years and 4 months.

When possible, new staff members were hired 1 to 3 months before the resignation of the person they would replace. Thus, it was possible for the departing staff member to relay to the replacement much of the knowledge that had been gained of the area, farmers, and institutions. Also, many departing staff members entered the Graduate College at Chapingo and continued to be available for advice and information.

The lines in Figure 2.1 show that there were 35 periods of employment in the Project. However, one staff member served both in evaluation and coordination, and a second in both evaluation and technical assistance; thus, there was a total of 33 staff members during the 7-year period. The total number of man-years of professional time varied from 2.2 in 1967 to 12.3 in 1971.

Beginning in 1967, young farmers in the Project area were hired to assist in the field activities. Initially they were hired as day laborers, but some of them were given permanent employment after a period of training and selection.

During 1967-1970, about 15 outstanding farmers were selected as permanent field assistants. Other farmers were hired as day laborers during the planting and harvesting seasons. As an average for the 1967-1973 period, the Project used approximately 25 man-years of the time of these employees.

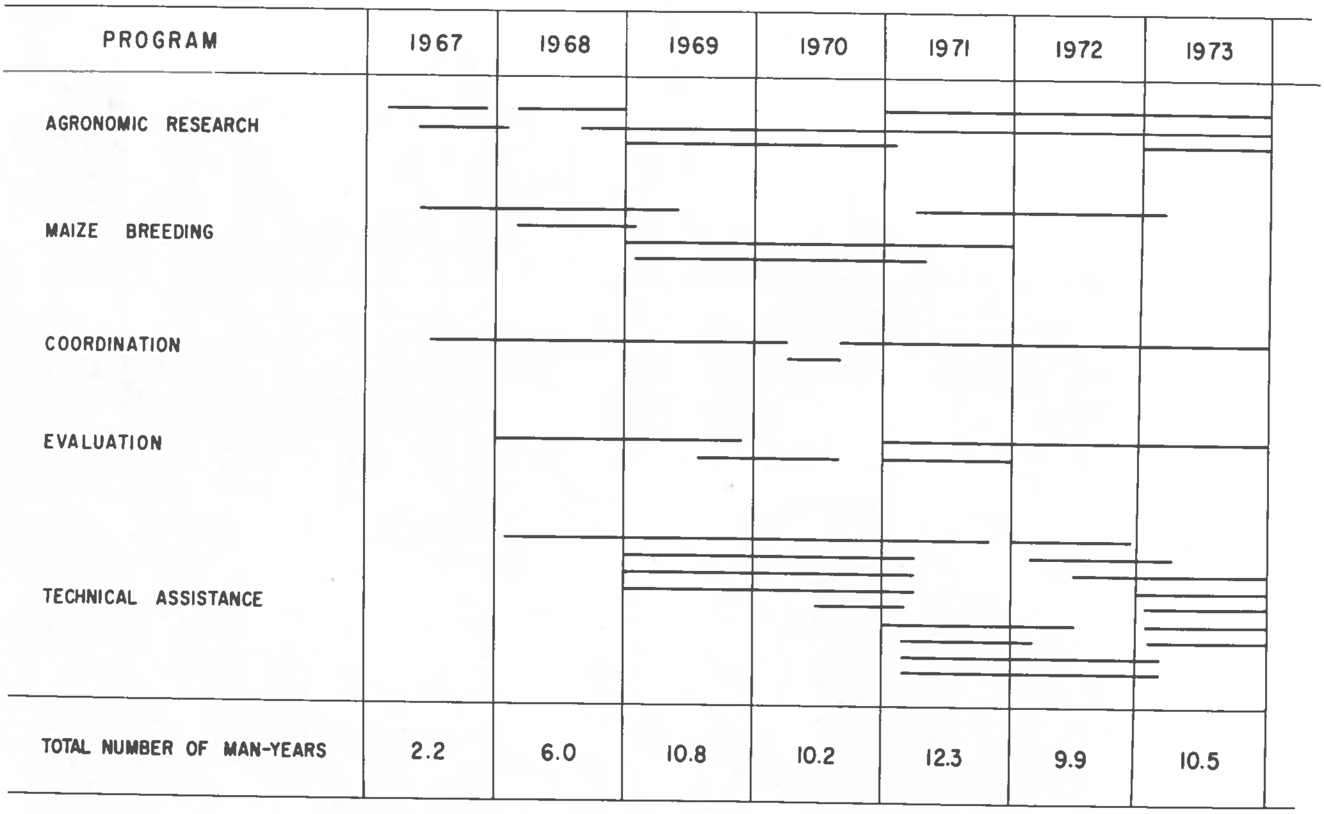
CONSULTING SERVICES

Specialists in agronomic research, maize breeding, and communications, at CIMMYT and the Graduate College at Chapingo, served as advisors to the Puebla Project. They drafted the original Project proposal, arranged for funding, selected the Project area, made the necessary arrangements with local institutions, prepared operational plans for 1967, and employed the first members of the Project team.

During the course of the Project, the advisors have assisted the Project staff in: (a) evaluating and modifying operational strategies, (b) preparing detailed plans for the Project at the beginning of each year, (c) defining appropriate methodological procedures, (d) resolving problems that have obstructed progress, (e) analysing and interpreting research findings, etc. In addition, the advisors have complemented the activities of the Project staff by: (a) anticipating Project growth and requesting funds needed for expansion; (b) giving wide distribution to Project findings through personal contacts, publications, and conferences; (c) projecting the Puebla approach to other areas in Mexico and Latin America by obtaining funds for travel, fellowships, equipment, etc.; (d) informing agricultural and political leaders of the Puebla experience; (e) planning and participating in a training facility at Puebla; and (f) providing assistance in the organization and operation of new programs.

The total time provided by the advisors in direct assistance in organizing and operating the Puebla Project averaged approximately 172 man-days per year for the 1967-1973 period.

Fig. 2.1. Periods of employment of professional staff in the five programs of the Puebla Project. Each line represents the period of employment of a staff member.



Field experiments were closely supervised during the crop growing season, and observations on factors affecting yield were made periodically. Here the height of unfertilized maize plants is being measured. To the right is a plot showing a strong nitrogen response.

3 AGRONOMIC RESEARCH

INTRODUCTION

Crop production on a given area depends on several factors, including soil and climatic conditions, plant variety, and production practices. The physical environment cannot be changed readily and thus determines the yield potential of a region. Varietal characteristics and management practices, however, are more easily manipulated, and improvement of these factors can provide higher yields and net income. Thus, agronomic research in the Puebla Project was designed to provide information on soil management practices and varieties that would produce higher returns for the farmers' production investments.

GENERAL STRATEGY

Production practices that can greatly influence crop yields in rainfed areas include: land preparation; planting date; seeding rate; amount and kind of fertilizers applied; time and method of applying the fertilizers; control measures for weeds, insects, rodents, and diseases; and depth of plowing. As a first step in developing better information on these agronomic practices, the Project sought to gather as much information as possible on farmers' production practices, soil and climatic characteristics, and the experiences of other researchers in the area. This information was gained by interviewing farmers and agronomists residing in the area, by reviewing the research findings of the National Agricultural Research Institute, by analyzing the available climatic data, and by studying the properties of the soils in the area. Through this process an understanding was obtained of the physical environment and the traditional technology of the farmers, as presented in Chapter 1.

A list of technological questions to be investigated was prepared and arranged in order of priority by taking the information available at the beginning of a given cropping season and estimating: (a) probable deficiencies in existing technology, (b) probable improvements that could be made economically, (c) which improvements would most likely provide the largest increases in yield and net income, and (d) which of these aspects of the technology should be investigated in the Puebla area.

Next, field experiments were carried out to answer questions of highest priority. The ecological diversity of the area was taken into account in planning the research and in locating the field trials. In 1967 and 1968, information on the physical environment was limited, and field experiments were distributed fairly evenly over the area. In 1969 and afterward, two or more producing systems were recognized in the area, and the experiments were located to sample these systems. (Note that a producing system is defined as a part of a production universe in which the uncontrollable production factors for a crop are reasonably constant. These factors include: soil morphology, geomorphology, climate, previous crop, and at times, planting date.)

During the growing season, observations were made periodically on the factors influencing production at each experimental site. The trials were harvested, data analyzed, and results expressed as treatment means or production functions. Data on crop response to rates of fertilization and plant density were expressed both as mathematical functions and as two-dimensional graphs, for greater certainty and ease of interpretation.

In 1967, the information available from the National Agricultural Research Institute was taken as a first approximation to the recommendations on crop production practices for the Puebla area. (The recommendation for rainfed maize in Puebla was: fertilize with 80 kg N and 40 kg P_2O_5/ha, use the hybrid H-28 with 40,000 plants/ha, and plant at the beginning of the rainy season.) Data collected in 1967 were used to revise the existing recommendations on maize production and to calculate a second approximation to the recommended practices. The data collected in subsequent years were used to generate third, fourth, fifth, etc., approximations.

Beginning in 1969, maize recommendations were formulated for distinct producing systems. All available information on climatic variability and prices for maize and inputs was taken into account in estimating the optimal levels of practices. Recommendations were made after carefully weighing: (a) the precision of the available information on the relationship between yield and the production factors, (b) the marginal productivity of the factors in question, and (c) the risk involved in making recommendations that might not be appropriate for the farmer.

The remainder of this chapter describes the agronomic research in the Puebla area in each year, 1967-1973. A final section seeks to evaluate the adequacy of the maize technology and to estimate the potential benefits of the improved technology, as compared with technology existing in 1967. Appendix A provides a benefit: cost analysis of the agronomic research program in the Project.

FIELD RESEARCH IN 1967

Information available at the beginning of 1967 indicated that maize production was the major agricultural activity in the Project area, accounting for the greater part of the available land, labor, and capital. Preliminary findings suggested that maize yields could be increased substantially under most farming conditions by: (a) increasing the rate of fertilization with nitrogen and phosphorus, (b) using higher plant densities, and (c) using better weed and insect control measures. There was evidence that fertilization with potassium, although a common practice, was not contributing to higher yields.

Based on existing knowledge, the initial reasoning was that optimal levels of fertilization with nitrogen and phosphorus would be greatly influenced by local conditions, thus should receive priority in the field research program in 1967. It was also concluded that optimum levels of factors such as time and method of applying fertilizers, plant density, genotype, and plant protection, which are generally less affected by local variations in soils and climate, could be estimated *a priori* from experiences gained in similar regions.

Thus, two hypotheses tested initially were: (a) production of rainfed maize in most of the area was being limited by the rates of nitrogen and phosphorus commonly used by farmers, and (b) fertilizing with potassium or zinc did not increase maize yields. In designing the experiments to test these hypotheses it was assumed that: (a) a population density of 50,000 plants/ha would be near optimal for the higher levels of fertilization with nitrogen and phosphorus that were thought to be needed, (b) the maize plantings should be kept free of weeds for the first 60 days after emergence, and (c) high-yielding local varieties were available for use in the experiments.

A field experiment was designed and installed at 23 locations distributed throughout the Project area. Treatments were used to measure the response of maize to levels of nitrogen and phosphorus fertilizer. The criteria of the cooperating farmers were used in deciding land preparation practices, the date and method of planting, and times of cultivating each experimental site.

The field trials were begun between April 18 and May 11. A composite soil sample was collected at each site. Rain gauges were installed near each experiment and arrangements made for the cooperating farmers to maintain a record of daily rainfall. The experiments were visited regularly during the growing season and data were collected on: (a) dates of all farming operations; (b) phenological dates; (c) vegetative response to treatments; and (d) damage due to drought, hail, frosts, lodging, excess water, weed and insect infestations, and diseases. A pit was dug at each experimental site and a description was made of the soil profile.

The experiments were harvested between October 6 and 25. The ears were harvested from the center rows of each plot, weighed, and the moisture content of the grain was determined. Observations were made on the percentage of rotten kernels, the pollination percentage, and the shelling percentage.

Results: 1967

The data collected during the growing season on factors influencing maize development were summarized for four distinct parts of the growth cycle: (a) from planting to 45 days prior to flowering, (b) the 45 days preceding flowering, (c) the 45 days after flowering, and (d) the period from the 46th day after flowering to physiological maturity.

Field experiments were conducted in cooperation with farmers at sites carefully selected to sample the variation in soils, climate and past management existing in the area. Here bags with different fertilizer treatments are being placed in the experimental plots just prior to application.

As soon as the maize reached maturity, the ears were harvested from the experimental plots, weighed, and grain samples were taken to determine the moisture content. The yield data from the field experiments were analyzed, interpreted, and used to develop new recommendations on crop production practices.

The growth cycle was subdivided in this way because the magnitude of the effect of most factors on maize yields has been shown to depend on the stage of development of the plant at the time the damage occurs. The effect of drought, for example, is greatest when it occurs during the second or third parts of the growing period. (Throughout this chapter, data are presented for these four parts of the growth cycle in their successive order, from planting through physiological maturity.)

For the 23 experiments conducted in 1967, on the average there were 0, 7.3, 6.4, and 0.1 days with visible wilting during the first, second, third, and fourth parts of the growing period, respectively. The highest frequency of drought occurred precisely in the two periods when maize is most susceptible to damage. In general, there was little damage due to hail, high winds, and frost.

Maize yields were increased significantly by the application of nitrogen and phosphorus in 21 of the 23 experiments. Fertilizers did not increase yields in one experiment where the soil was naturally very fertile, nor at a second location where drought was severe and a poorly adapted variety was used.

Average treatment yields in each experiment were used to calculate a quadratic equation with maize yield expressed as a function of rates of nitrogen and phosphorus. These equations were used to estimate the optimal rates of fertilizer for each experiment. The partial derivatives of yield with respect to nitrogen and phosphorus were equated to the ratio of the cost of the corresponding fertilizer to the price of the maize. This resulted in two equations in two unknowns whose simultaneous solution gave the optimal rates of nitrogen and phosphorus for each experiment.

The estimated optimal rates of nitrogen in the 23 experiments varied from 0 to 221 kg/ha, with an average of 109 kg/ha. Optimal rates of phosphorus varied from 0 to 128 kg P_2O_5 /ha, with an average of 30 kg/ha. The maize yields were calculated for each experiment corresponding to the estimated optimal rates of nitrogen and phosphorus; these varied between 2,128 and 7,068 kg/ha grain, with an average of 4,137 kg/ha. The average yield without fertilizer in the 23 experiments was 1,326 kg/ha. Thus, the average increase in yield produced by the estimated optimal levels of fertilization was 2,811 kg/ha.

Results of the 1967 experiments were used to arrive at a second approximation to the recommended package of production practices for maize. Because a decision had been made to limit promotional activities in 1968 and 1969 to Zones I through IV, however, a second approximation was derived specifically for that portion of the Project area (see Figure 1.1). Fifteen of the experiments conducted in 1967 had been located in Zones I through IV. The optimal rates of nitrogen for these 15 experiments varied from 60 to 221 kg/ha, with an average of 128 kg/ha. The optimal rates of phosphorus for the same experiments varied from 0 to 128 kg/ha, P_2O_5, with an average of 37 kg/ha.

Two conditions suggested that the recommended levels of nitrogen and phosphorus should probably be slightly greater than the average optimal levels calculated from the 1967 results: (a) historical rainfall data and information from farmers indicated that drought during the flowering period of the maize crop (July and August) had been unusually severe in 1967 it was probable that, in most years, reductions in yield due to drought would be less than those observed in 1967; and (b) one of the varieties used in the experiments seemed poorly adapted in two locations--responses to fertilization at those sites would probably have been greater with a better-adapted variety.

It was decided, therefore, to recommend 130 kg/ha N plus 40 kg/ha P_2O_5 for maize plantings in Zones I through IV in 1968. One-tenth of the nitrogen and all the phosphorus were to be applied at planting time; the rest of the nitrogen was to be applied just before the second cultivation. A population density of 50,000 plants/ha was to be used, and the plantings were to be kept free of weeds during the 60 days following emergence.

It was estimated that this revised recommendation would produce an average increase in yield of 3,066 kg/ha. Estimated costs of this package of practices, mainly fertilizer costs, were equivalent in value to 1,795 kg/ha maize. The expected average net increase in grain production was 1,271 kg/ha. Two additional sources of income would be associated with the use of the recommendation: (a) yields of stover would be increased proportionately to that of grain and could be sold or used on the farm; and (b) the higher labor requirements for applying fertilizers, harvesting, and shelling the maize would increase family employment and family income.

The soil samples collected at the 23 experimental sites were analyzed for nitrifiable nitrogen and available phosphorus. The experiments were divided into four groups, depending on whether the levels of nitrifiable nitrogen and available phosphorus were less than, or greater than, 10 parts per million parts of soil (ppm). The value of 10 ppm was selected arbitrarily, to permit a comparison of soil test levels and average optimal rates of nitrogen and phosphorus. The average optimal levels of nitrogen and phosphorus for the experiments in each group are shown in Table 3.1.

TABLE 3.1. The average optimal fertilizer rates for soils containing different amounts of nitrifiable nitrogen and available phosphorus.

		Available phosphorus (ppm) (Bray P_1 Method)		Weighted average N rate
		<10	>10	
Nitrifiable nitrogen (ppm)	< 10	141-49(10)*	130-9 (5)	137
	> 10	90-37(2)	44-12(6)	55
Weighted average P_2O_5 rate		47	10	

* The first number is the average optimal rate of nitrogen, the second is the average optimal rate of P_2O_5, and the third, in parenthesis, is the number of experiments corresponding to the group.

The average optimal rates of nitrogen were 137 kg/ha for soils containing less than 10 ppm of nitrifiable nitrogen and 55 kg/ha for soils containing more than 10 ppm. The average optimal rates of P_2O_5 were: 47 kg/ha for soils containing less than 10 ppm of available phosphorus; and 10 kg/ha for soils containing more than 10 ppm. This promising relationship between optimal rates of fertilization and levels of available soil nutrients prompted the staff and consultants of the Puebla Project to explore the possibility of using soil analyses as an aid in determining fertilizer recommendations for Puebla farmers. Unfortunately, it was not possible to provide an efficient soil testing service for the farmers, and the Puebla Project was not able to make use of this resource.

FIELD RESEARCH IN 1968 AND 1969

The experiments in 1967 suggested that under unfavorable conditions (severe drought, shallow soils), the population density of 50,000 plants per hectare was probably too high. For certain favorable production conditions (little or no drought, deep soils) the same plant density appeared to be too low. Thus, it was decided to study levels of plant density along with levels of nitrogen and phosphorus.

It was also decided that experimental verification was needed for the hypothesis that significant amounts of moisture were conserved by fall plowing.

Observations of the traditional land preparation practices of the farmers during the winter of 1967-1968 led the research staff to question the effectiveness of these practices for several reasons: (a) there is little weed growth during the winter, thus little moisture should be lost, even without plowing; (b) February and March are windy months, and leaving the surface bare might foster wind erosion; and (c) the organic matter contents of the soils are very low, and plowing the soil would tend to accelerate the mineralization of the organic matter.

Another question arose in 1967 about the way farmers made their last cultivation. Most farmers cultivated very deeply with a double moldboard plow and pruned many of the lateral maize roots. This also seemed to be a factor for local study.

Experiments on farmers' fields were used to obtain information on rates of fertilization, time on applying nitrogen and phosphorus, dates of planting, methods of land preparation, residual effects of fertilizers and manures, and other production practices.

Deep, volcanic ash soils occupy about two-thirds of the project area. By plowing in the fall, farmers are able to conserve much of the moisture present in the soils at harvest time. Just prior to planting, the farmer plows deep furrows and plants the maize in holes opened with a spade in the bottom of the furrows.

In parts of the Project area (particularly in Zone II), much of the maize is grown in fruit orchards in the space between rows of trees. It seemed likely that the effect of the trees on the production of maize would vary depending on: (a) the fruit specie, (b) the amount of space between rows of trees, and (c) the size of the trees. Beginning in 1968, experiments were conducted to determine optimal levels of fertilization for maize growing in fruit orchards, taking into account the distinct characteristics of the orchards.

As shown in Table 3.2, plant densities, methods of land preparation, depth of the last cultivation, and rates of fertilization of maize in orchards were new lines of research in 1968. Studies on dates of planting were added when it became evident in 1967 that farmers planted maize from mid-March until late June. The research staff also decided to include studies of times of applying fertilizers and the residual effects of fertilizers to develop more reliable information about these factors.

The research program in 1969 (Table 3.2) was similar to that of 1968. The principal new line of research was the study of application rates for manure and fertilizers. In 1968, it had been observed that farmers' plantings that had received chicken manure that year, or chemical fertilizer that year and chicken manure during the preceding three-year period, were often more vigorous than the best experimental treatments. This suggested the possibility of a nutritional deficiency other than nitrogen and phosphorus. It was decided to include experiments in 1969 to determine economically optimal combinations of nitrogen, phosphorus, and chicken manure. In addition, the experiments were planned so that residual effects of the manure could be measured.

Two other lines of research were initiated in 1969: (a) optimal rates of nitrogen, phosphorus, and plant density for forage maize; and (b) effect of minimal tillage on maize yields. In addition, the use of a "potential yield" treatment in many of the experiments was begun that year. This treatment consisted of 10 ton/ha of chicken manure, plus chemical fertilizers (140 or 160 kg/ha N plus 50 kg/ha P_2O_5). It was assumed that this treatment would provide all maize nutrition requirements.

A total of 47 field experiments were conducted in 1968 and 1969 (Table 3.2). Composite soil samples were collected at each experimental site from the plow layer (0-18 cm) and from the subsoil (20-35 cm), for property characterization.

TABLE 3.2. Lines of research in maize and numbers of field experiments conducted in the Puebla area in 1968 and 1969.

Lines of research	Number of experiments 1968	1969
Rates of nitrogen, phosphorus and plant density	8	12
Rates of nitrogen, phosphorus and plant density in maize for forage	0	1
Rates of nitrogen, phosphorus and manure.	0	3
Dates of planting	4	2
Times of applying fertilizers	2	5
Depth of the last cultivation	2	0
Rates of nitrogen and phosphorus for maize in orchards	2	2
Methods of land preparation	1	0
Minimal tillage	0	1
Residual effects of fertilizers	1	1
Total	20	27

Results: 1968 and 1969

Conditions in 1968 were favorable for the production of maize. The average numbers of days per experiment with plant wilting were 1.2, 1.7, 2.0, and 0 days during the four successive parts of the growing cycle. In three of the 20 experimental sites there was slight damage due to hail during vegetative development, but no damage during the grain-filling period. There was slight or moderate frost damage during the first part of the growing cycle in half of the experiments.

In contrast, 1969 was a poor year for maize production. Plant wilting occurred on an average of 14.1, 14.1, 0.5, and 0 days during the four parts of the growing cycle. In several of the experiments, the plants began to wilt two weeks after emergence and continued under moisture stress until a week or so before tasseling. Slight to severe hail damage occurrred in one-third of the experiments during the first, second, or third parts of the growing period. Frost did not affect the maize plantings in 1969.

Studies of soil morphology done in 1968 revealed a large region in the northwestern part of the Project area in which the subsoils were sufficiently dense and compacted to restrict water movement and the penetration of maize roots. Two producing systems were thus recognized and taken into account in the interpretation of the experimental results in 1968: (a) deep soils of Popocatépetl, comprising Zones III, IV, and parts of I and II; and (b) soils with a compact layer impeding root development comprising parts of Zones I and II.

The economically optimal rates of nitrogen for the experiments conducted in deep soils in 1968 varied from 133-200 kg/ha, with an average of 187 kg/ha. The optimal rates of phosphorus varied from 50-100 kg/ha P_2O_5, with an average of 81 kg/ha. Optimal population densities varied from 42,000-70,000 plants/ha with an average of 64,400 plants/ha. Grain yields, using these optimal treatments, varied from 4,510-8,790 kg/ha, with an average of 7,462 kg/ha. The average increase in grain yield above the control treatment was 6,434 kg/ha.

For the producing system in which the soils have a compacted horizon, the average optimal rates of nitrogen, phosphorus, and population density were 106 kg/ha, 58 kg/ha P_2O_5 and 55,333 plants/ha, respectively. The average yield obtained using the optimal treatments was 4,847 kg/ha grain; the average increase over the control treatment was 3,443 kg/ha. Clearly, for a favorable year like 1968, the two producing systems differ markedly both in their potential for maize production and in the optimal rates of nitrogen fertilization.

The overall average grain yield in 1968 using the optimal treatments was 5,312 kg/ha more than that obtained with the control treatment. This compares with an average increase of 3,292 kg/ha in 1967 for the experiments conducted in the same area. This difference was due primarily to more favorable rainfall in 1968 and the flexibility introduced by including plant density in the experimental matrix.

The results obtained in 1968 indicated that the recommended rates of nitrogen, phosphorus, and plant density should be increased for the producing system with deep soils. However, because 1968 was a very favorable year, it was decided to increase only the rate of phosphorus by 10 kg/ha P_2O_5.

For the system with soils having a compacted horizon, the revised recommendation was for 20 kg/ha less nitrogen and 10 kg/ha more P_2O_5. Thus, the third approximation of the maize recommendations was: (a) 130 kg/ha N, 50 kg/ha P_2O_5, and 50,000 plants/ha for deep soils; and (b) 110 kg/ha N, 50 kg/ha P_2O_5 , and 50,000 plants/ha for soils with a compacted horizon. For the other production practices, the recommendation remained the same as in the previous year.

Studies of soil morphology done in 1969 identified a large area of sodic-like soils in Zone IV. It was also found that most of the soils in Zone V had formed on volcanic ash derived from the volcano, La Malinche. According to field response to fertilizers, these soils were well supplied with phosphorus. Thus, four producing systems were recognized in the interpretation of experimental results in 1969, including: (a) deep soils of Popocatépetl; (b) soils of La Malinche, and two other systems with soils having a compacted layer impeding root development; (c) those comprising parts of Zones I and II and recognized first in 1968; and (d) the sodic-like soils in Zone IV.

Even with the unfavorable rainfall regime in 1969, the deep soils of Popocatépetl yielded well and reflected the need for a high rate of nitrogen fertilization. The best yields obtained in 1969 on the soils with a compacted horizon in Zones I and II were much lower than those obtained in 1968. The soils of La Malinche showed a lower yielding potential than the deep soils of Popocatépetl under the unfavorable climatic conditions in 1969. Even though maize yields were increased by fertilization on the sodic-like soils, maximum grain yields on these soils barely reached 1,500 kg/ha. Maize yield on the sodic-like soils were limited mainly by excess moisture during the first three parts of the growing season.

The studies on rates of fertilization of maize in orchards showed that the two rows of maize on either side of the rows of trees should receive less fertilizer than the other rows. The fourth approximation of the maize recommendations is presented in Table 3.3.

The study of the traditional method of land preparation provided strong evidence that the moisture content of the soil and the per cent emergence of maize planted the following spring were lower when the soil was not plowed during the late fall, than with traditional practices. The study of depth of plowing detected no significant reduction in yield due to deep plowing at the last cultivation.

Date of planting and time of applying nitrogen showed contrasting effects on yield in 1968 and 1969. Maize planted during the first week of April in 1968 yielded 2,000 kg/ha more than maize planted three weeks later. In 1969, maize planted on the later date yielded 1,000 kg/ha more than that planted three weeks earlier. In 1968, maize yields were 600 kg/ha higher when 150 kg/ha N were applied at the second cultivation, rather than at planting time. In 1969, yields were 1,200 kg/ha higher when 150 kg/ha N were applied at planting time, rather than at the second cultivation.

These contrasting effects of date of planting and time of applying nitrogen seem to stem from differences in the amount and distribution of rainfall during the two years. The monthly rainfall for 1968 and 1969, and the monthly averages for the 1941-1968 period are shown graphically in Figure 3.1.

In 1968, rainfall in May was average, and in June it was 20 percent above the average. Thus, adequate moisture was available in 1968 during the vegetative development of early plantings of maize. In 1969, on the other hand, rainfall in May was 40 percent of the 1941-1968 average; in June, 27 per cent; and in July, 73 per cent of that average. Thus, early plantings of maize suffered severe moisture stress during May, June, and early July.

The higher yields from the later plantings in 1969 appear to be due to the fact that these plantings had a longer period in which to produce a large plant than did the early plantings, after the rains began in July. The better response to nitrogen applied at planting time in 1969 was probably because moisture deficiencies delayed absorption of nitrogen applied at the second cultivation until the plants were too old to make maximum use of the nitrogen.

In 1969, it also was noted that certain maize varieties, after being under moisture stress for several weeks, were able to delay tasseling for one to two weeks, thereby developing larger plants and producing higher yields. This characteristic of "latency" was important in 1969, but not in 1968.

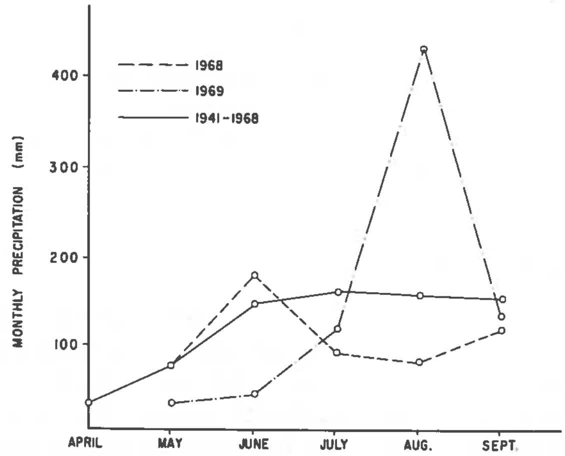


Fig. 3.1. Average montly rainfall in Zones I-IV of the Puebla Project for 1968, 1969, and the period 1941–1968.

FIELD RESEARCH IN 1970

The interactions observed between rainfall pattern and date of planting, time of applying nitrogen, and maize variety, in 1968 and 1969 suggested that it would be advantageous to make integrated studies of yield response to these variables, plus rate of fertilization and plant density. Six such integrated studies were conducted in 1970, along with studies of maize response to rates of nitrogen, phosphorus, and plant density in six experiments located to sample regions that had not been studied previously.

Research on bean production was initiated in 1970. Major emphasis was placed on bush beans (determinate growth habit) and lesser attention was given to the association of maize with pole beans (indeterminate growth habit).

TABLE 3.3. Fourth approximation of the maize recommendations for the Puebla area.

Producing system	Kg/ha of fertilizers applied at: Planting time N	Planting time P_2O_5	First cultivation N	First cultivation P_2O_5	Second cultivation N	Second cultivation P_2O_5	Total fertilizers applied (kg/ha) N	Total P_2O_5	Population density (Plants/ha)
1. Deep soils of Popocatépetl									
1.1. Maize alone	30	50	0	0	100	0	130	50	50,000
1.2. Maize in orchards									
1.2.1. Two rows on either side of the trees	30	50	0	0	50	0	80	50	50,000
1.2.2. Other rows	30	50	0	0	100	0	130	50	50,000
2. Soils of La Malinche	0	0	80	0	0	0	80	0	40,000
3. Soils with a compacted layer impeding root development.									
3.1. Non-sodic	20	50	0	0	90	0	110	50	50,000
3.2. Sodic-like	Do not grow maize								

A collection was made of 24 local bush varieties and 18 pole varieties. The response of bush beans to rates of fertilization and plant density was studied at six locations. The varieties collected in Puebla were evaluated at three sites. The maize-bean association was studied at one location.

Results: 1970

The rainfall pattern in 1970 was quite favorable for both maize and beans. In the several experiments, maize wilted an average of 6.2, 0.7, 0, and 0 days during the four parts of the growing cycle. Hail damage occurred in one-third of the experiments during the first part of the growing season; in the other three parts, hail affected the maize in only one-tenth of the experiments. In most of the plantings, maize was damaged slightly by frost during the first part of the growing period.

Table 3.4 shows the average maize yields obtained at two locations using several combinations of fertilization, plant density, genotype, and date of planting. The average grain yields for the 16 treatments were 5,352 kg/ha for the first planting date, 4,446 kg/ha for the second date, and 2,029 kg/ha for the third.

There were large interactions between planting date and other factors, including: (a) Planting Date x Rates of Fertilization and Plant Density: comparison of the yields obtained with Treatments 2 and 14 shows that the higher rate of fertilization and plant density outyielded the lower rate by 3,703 kg/ha in the first planting, 3,166 kg/ha in the second planting, and by only 575 kg/ha in the third planting. A similar comparison of the Control Treatment (1) and the "Potential Yield" Treatment (15) indicates that Treatment I yields (no fertilizer) were 15 per cent of Treatment 15 yields for the first planting date, 12 per cent for the second date, and 6 per cent for the third. This seems to imply that a given soil can supply more nutrients to early plantings than to later plantings; (b) Planting Date x Fertilization with Phosphorus: the magnitude of this interaction can be judged by comparing yields of Treatments 4 and 5, Treatments 7 and 9, and Treatments 8 and 10, at the three dates of planting. The increase in yield due to phosphorus is less than the least significant difference (LSD) for the first planting date, and is clearly greater than the least significant difference for the second and third planting dates. In these experiments the same soil required less phosphorus and produced higher yields in early plantings than in later plantings; (c) Planting Date x Genotype: comparison of treatments 15 and 16 shows that the yield obtained with the Composite A x B was 91 percent of that produced by the hybrid maize for the first planting date, 120 per cent for the second date, and 135 per cent for the third; and (d) Planting Date x Kind of Fertilizer: comparisons of treatments 14 and 15 for the first and second plantings, and Treatments 12 and 15 for the third planting, show that the best yield obtained with chemical fertilizers alone was 82 per cent of that obtained with chemical fertilizers plus manure for the first planting date, 76 per cent for the second date, and 54 per cent for the third.

TABLE 3.4. Average maize yields obtained at two locations using several combinations of fertilization, plant density, genotype, and date of planting.

No. of Treatment	Nitrogen (kg/ha) applied at: Planting time	First cultivation	Second cultivation	Phosphorus (kg P_2O_5/ha) at planting	Population density (plants/ha)	Yield in kg/ha Planting date* May 3	May 23	June 13
1	0	0	0	0	30,000	1306	932	234
2	0	50	0	25	30,000	3315	2771	1469
3	0	80	0	0	30,000	3869	2264	875
4	0	105	0	0	30,000	4303	2749	1128
5	0	105	0	40	30,000	4253	3788	1912
6	0	105	0	40	50,000	5399	4103	2235
7	0	130	0	0	30,000	4592	2641	1240
8	0	130	0	0	50,000	5539	3511	1600
9	0	130	0	40	30,000	5006	4048	1794
10	0	130	0	40	50,000	5907	4788	2358
11	30	0	100	40	50,000	6079	5311	1875
12	30	0	100	40	60,000	5989	4958	2179
13	30	0	130	40	60,000	6748	5946	2089
14	30	0	160	40	60,000	7018	5973	2044
15**	30	0	130	40	60,000	8533	7872	4018
16**	30	0	130	40	60,000	7778	9475	5420
					AVERAGES	5352	4446	2029
				LSD	5%	532	794	364

* The hybrid, H-129, was used for the May 3 planting. The hybrid, H-28, was used for the plantings on May 23 and June 13.

** These treatments include an application of 10 ton/ha of chicken manure. The composite variety A x B (see Chapter 4, page 40) was used in treatment 16.

Results similar to those shown in Table 3.4 were obtained in the other integrated studies. Based on these data, it was decided to make a separate recommendation for late plantings. This recommendation would use 30 kg less nitrogen per hectare and 10,000 fewer plants per hectare than the recommendation for early plantings. For soils with a compacted horizon, a small reduction in the phosphorus rate was also recommended for late plantings.

A fifth approximation of the recommended production practices for maize was calculated at the end of 1970, taking into account all information available at that time. Distinct packages of practices consisting of rates of fertilization and plant density were recommended for 16 producing systems, varying mainly because of differences in soil morphology, planting date, and use for fruit trees.

Bush bean yields in the six experiments were influenced by rates of fertilization and plant density. Average optimal levels were 67 kg/ha N, 53 kg/ha P_2O_5, and 112,500 plants/ha. The average yield obtained with the optimal treatments was 1,951 kg/ha beans. When no fertilizer was used, the average yield was 780 kg/ha. The cost of the average optimal treatment was equivalent to 605 kg beans with a price of $0.12/kg and to 363 kg beans with a price of $0.20/kg. Even at the lower price for beans, which rarely occurs, the average increase in yield using the optimal treatments was almost double the cost of the treatments.

These data were used to arrive at a first approximation of production practices for bush beans: (a) for deep soils of Popocatépetl and soils with a compacted horizon: 60 kg/ha N, 60 kg/ha P_2O_5, and 120,000 plants per hectare; and (b) for the soils of La Malinche: 60 kg/ha N, 30 kg/ha P_2O_5, and 120,000 plants per hectare. The recommendations of the National Agricultural Research Institute for the control of the bean beetle, *Epilachnia varivestis* (known locally as "conchuela") were to be followed, with the farmer to select the variety, the date of planting, and the time to cultivate.

Results obtained in the study of the maize-bean association indicated that this cropping system might provide greater net income to Puebla farmers than either maize or beans grown alone.

FIELD RESEARCH IN 1971

Integrated studies of the effects of planting date, fertilization, and plant density were continued at four locations in 1971. It was decided to continue these experiments for several years to accumulate information on the interaction between these factors and climatic conditions.

Data from the integrated studies conducted in 1970 indicated that investigations of efficient management practices for late maize planting should take these factors into account: (a) existing short-season varieties have a relatively low-yielding ability, as compared to long-season varieties; (b) there are probably nutrient deficiencies other than nitrogen and phosphorus; and (c) light intensities and temperatures are relatively low, and available soil moisture abundant, in the initial stages of plant growth.

Three experiments were conducted at a single location in 1971 to determine optimal production practices for late plantings of maize. These experiments covered three topics: (a) exploration of the yielding ability of six varieties, (b) study of the response of a local maize variety to five minor elements, and (c) study of the response of an introduced maize variety to fertilization with nitrogen, phosphorus, and chicken manure, and to plant density.

The response of maize to five rates of nitrogen and phosphorus or nitrogen and plant density was studied at 10 locations to produce data for calculating the most adequate mathematical model to represent maize response to these factors (thesis research of a graduate student at Chapingo).

Experiments at six locations studied optimal levels of fertilization and plant density for bush beans. Two experiments compared net income from the maize-bean association with that obtained from maize and beans grown alone (pole beans were used in one experiment and bush beans in the other).

A series of experiments at two locations sought to identify crops that might be grown instead of maize in years when the rains do not begin until July. Maize planted as late as July runs a high risk of being damaged by frost in the fall. Included in this series were sunflowers for forage, bush beans, horse beans, oats, barley, and maize.

Results: 1971

The rainfall pattern in 1971 was quite favorable for both maize and beans. In the maize experiments, the average numbers of days with plant wilting were 8.7, 0.4, 0, and 0 for the four parts of the growing cycle. Slight to severe hail damage occurred in the first, second, or third parts of the growing cycle in 10 maize experiments. Slight to severe frost damage occurred in the first part of the growing cycle in four maize plantings. None of the bean experiments was damaged by drought, hail or frost. Bush beans suffered moderate leaf damage due to anthracnose disease at three sites.

Only one of the early-maturing maize varieties studied in 1971, Rojo Salvatori, showed a reasonably high yielding ability. Table 3.5 compares this variety with Zacatecas 58, which had the next highest yields. The Rojo Salvatori yield at the highest level of fertilization and plant density was

TABLE 3.5. Grain yields obtained with two early-maturing maize varieties receiving different fertilization and plant density treatments.

Nitrogen kg/ha	P_2O_5 kg/ha	Population density plants/ha	Chicken manure ton/ha	Grain yields (kg/ha) using Zacatecas 58	Rojo Salvatori
60	50	40,000	0	1237	1448
100	50	60,000	0	833	1840
150	80	80,000	0	1168	2870
120	80	80,000	10	2030	2537
200	100	100,000	0	1098	1676
200	100	120,000	0	1563	1354
150	100	120,000	20	1491	3147
150	100	150,000	20	2597	4317

three times that obtained at the lowest level of fertilization and plant density.

The studies of the maize-bean association demonstrated that net income from the association was approximately double that obtained with either maize or beans alone. Horse beans, bush beans, oats, and barley all showed some advantage over maize for late plantings. The data obtained in the study of the response of an early maize variety to minor elements was inconclusive.

In 1971, the production of maize became somewhat more profitable for farmers, due to several factors: (a) the price of nitrogen fertilizers was reduced by about 14 percent; (b) the maximum moisture content acceptable in grain purchased at the guaranteed price was increased from 12 to 14 percent; (c) the practice of paying less for colored grains was discontinued, and (d) the CONASUPO, the National Marketing Agency, agreed to purchase maize in small lots.

These changes prompted Project decisions to increase the recommended rate of nitrogen fertilization in Zone V from 80 to 100 kg/ha and the population density from 40,000 to 50,000 plants/ha. It was decided not to change the recommendations for the rest of the Project area, but to develop alternative recommendations that would cost about one-half to two-thirds as much as the existing recommendations. It was expected that the technical assistance agents would provide information to the farmers about costs, expected net incomes, and risks involved in the alternative recommendations. The farmer would decide which alternative to adopt, or how much land to allot to each recommendation. This innovation was designed initially for early plantings (those made with residual moisture).

FIELD RESEARCH IN 1972

Results obtained with the maize-bean association in 1970 and 1971 were promising; thus, more resources were allotted to the study of this cropping system. Six experiments in 1972 measured the response of the association to several rates of nitrogen, phosphorus, and plant density of maize. These experiments were located in the important producing systems of Zones I, II, and IV, where this cropping system is commonly used.

Beginning in 1968, average maize yields were estimated each year at harvest time on samples of two categories of farmers: (a) farmers on credit lists (who were organized in groups, received credit from institutions participating in the Project, and could be expected to use the Project recommendations), and (b) all farmers in the area (see Chapter 8).

TABLE 3.6. Average yields, protein percentages, and net incomes for several treatments in maize-bean association experiments conducted at three locations in 1972.

Treatment No.	Fertilizers (kg/ha) applied: N	P_2O_5	Population density of maize* plants/ha	Grain with 14% moisture: Maize	Beans	Percent protein**	Net income with bean prices/ton at+: $240	$160
1	120	40	30,000	2987	1300	8.6; 22.0	404.64	300.64
2	120	40	40,000	3306	1246		410.88	311.20
3	120	80	30,000	2962	1548		440.72	316.80
4	120	80	40,000	3074	1393	8.3; 21.8	414.40	304.08
5	150	40	30,000	2796	1575		442.00	315.92
6	150	40	40,000	3758	1361		451.36	298.80
7	150	80	30,000	3006	1575	8.7; 22.4	441.44	317.84
8	150	80	40,000	3559	1398	8.7; 22.4	436.00	324.16
9	90	40	30,000	2619	1150	8.3; 21.0	357.60	265.60
10	180	80	40,000	3737	1488	9.0; 23.0	449.04	330.00
11	150	0	40,000	3156	1445	8.5; 22.9	440.48	324.88
12	150	80	20,000	2217	1641		397.92	266.64
13	150	40 + CM++	40,000	4056	2446	9.4; 24.5	557.04	361.36
14	120	40	40,000	4634	0	8.5	244.24	244.24
15	60	60	0	0	1222	20.9	194.08	96.40
			LSD	575	225			

* Population of beans was constant at 60,000 plants per hectare.

** The protein percentage of maize appears first followed by that of beans. Each value is an average of 15 determinations. The analyses were made by biochemist Francisco J. Rodríguez B. of the CIMMYT Protein Quality Laboratory.

\+ Net income was calculated as gross income minus variable costs. The value of maize grain was calculated at $72.00 per ton and the value of stover at $8.00 per ton.

++ Ten tons per hectare of chicken manure.

In general, average yields of farmers on credit lists were only about two-thirds as large as they might have been, according to the results obtained in the field experiments. This finding suggested studies to determine why the farmers on credit lists did not have higher yields.

In each of the Zones II and V, sixty parcels representing 60 farmers on credit lists were chosen at random. A representative area was selected within each parcel consisting of 12 rows, 10 meters long. One of the two alternative maize recommendations was used on six rows of each parcel in Zone II, with the other alternative used on the other six rows. In Zone V, the more costly alternative was used on six rows of each parcel, with the same recommendation, plus 50 kg/ha P_2O_5, used on the other six rows. The latter treatment was included to test phosphorus needs of maize fields in Zone V.

These two plots in each of the selected parcels were managed by Project research agronomists. In addition, the agronomists made regular observations of the production practices used by the owners of the parcels, supplementing this information with data collected directly from the farmers.

Additionally in 1972, two field experiments were made to: (a) determine if weed problems were greater in fields using Project recommendations than in fields using the traditional technology, and (b) evaluate the profitability of the intensive weed control methods in the Project recommendations. It had been found that many farmers had the impression that weed control was more difficult in fields where the Project recommendations were used, and there was concern that this feeling might discourage farmers from adopting the new technology.

The weed control experiments consisted of 12 treatments. Project recommendations were used in half the treatments and the traditional technology in the other half. Several weed control measures were used with each of the technologies. The more intensive weed control practices consisted of hand weeding at different growth stages, and the use of herbicides. The experimental plot consisted of six rows, each 5 meters long. A randomized complete block design with six replications was used.

Results: 1972

Conditions in 1972 were excellent for maize and beans, perhaps comparable to 1968. In 24 experimental plantings of maize, or of maize associated with beans, the average numbers of days with wilting of the maize plants were 0.5, 1.0, 0, and 0.9 for the four parts of the growing cycle. The corresponding averages for 1968 were similar: 1.2, 1.7, 2.0, and 0. Hail and frost damage in 1972 were also slight.

Table 3.6 shows average yields, protein percentages of the grain, and net incomes for treatments used in three maize-bean association experiments conducted in the deep soils of Popocatépetl. The inclusion of 60,000 plants/ha of beans in a planting of maize with 40,000 plants/ha, fertilized with 120 kg/ha N and 40 kg/ha P_2O_5 resulted in: (a) a decrease in the maize yield of 1,328 kg/ha (Treatment 14 minus Treatment 2); (b) production of 1,246 kg/ha beans; and (c) an increase in net income per hectare of $166.64 with beans priced at $240/ton, or $66.96 with beans priced at $160/ton.

Bean production increased remarkably when 10 ton/ha of chicken manure was added to the treatment consisting of 150 kg/ha N, 40 kg/ha P_2C_5, 40,000 plants/ha of maize, and 60,000 plants/ha of beans. Comparison of bean yields obtained with Treatments 6 and 13 shows that the increase due to manure was 1,085 kg/ha. Part of this increase in bean yield was probably due to the nitrogen and phosphorus contained in the manure. Most of the increase, however, was apparently due to some different, undetermined cause. The net income from the maize-bean association receiving both chicken manure and chemical fertilizers (Treatment 13) was 2.28 times that derived from maize planted alone, with beans priced at $240/ton. The protein percentage of the beans fertilized with chicken manure was 1.5 percent points higher than that of the beans receiving the highest rate of chemical fertilizers (24.5 versus 23.0 percent).

Table 3.7 compares the amounts of protein and lysine produced by common maize planted alone, and by the maize-bean association, with the amounts produced by opaque maize. Opaque maize produced nearly twice as much lysine per hectare as did common maize. The common maize-bean association, fertilized with nitrogen and phosphorus, produced 59 percent more lysine than did opaque maize alone. The common maize-bean association, fertilized with nitrogen, phosphorus, and chicken manure, produced 2.39 times as much lysine as opaque maize alone.

TABLE 3.7. The amounts of protein and lysine produced by common and opaque maize planted alone, and by the common maize-bean association.

	Protein		Lysine *	
	kg/ha	% of Opaque	kg/ha	% of Opaque
Common maize, planted alone	394	93	9.9	52
Opaque maize, planted alone**	423	100	19.9	100
Maize-bean association with 150 kg/ha of N, 80 kg/ha of P_2O_5 and 40,000 plants/ha of maize	623	147	30.3	159
Maize-bean association with 150 kg/ha of N, 40 kg/ha of P_2O_5, 10 ton/ha of chicken manure and 40,000 plants/ha of maize	981	232	45.5	239

* In calculating the production of lysine per hectare, the protein of beans and common maize was assumed to have 7.2% and 2.5% lysine, respectively. For bean protein from the treatment with the chicken manure, it was assumed that the percentage of lysine dropped to 6%. Source: Mercedes Hernández, *et al.*, 1971. Valor nutritivo de los alimentos; Tablas de uso práctico. Publicaciones de la División de Nutrición-L-12, 5a. Instituto Nacional de la Nutrición, México. p. 20.

** Based on data from an experiment carried out on the deep soils of Popocatépetl. The best opaque variety yielded 4,700 kg/ha with 50,000 plants/ha and fertilized with 130 kg/ha of nitrogen plus 50 kg/ha of P_2O_5. It was assumed that the grain contained 9% protein and that the protein had 4.5% lysine.

The opaque maize would have had to yield 11.3 ton/ha to equal the production of lysine by this maize-bean association in 1972. An association of pole beans with an opaque maize would seem certain to yield an even higher production of lysine per hectare.

The study of the use of technology by the farmers on credit lists disclosed that farmers' yields on the average were lower than those obtained in the parcels controlled by the research agronomists. The average yield of the farmers' parcels in Zone II was 3,444 kg/ha and for the control plots within these parcels it was 4,725 kg/ha. In Zone V, the farmers' yields averaged 4,076 kg/ha versus a control yield 4,841 kg/ha. The lower yields obtained by farmers can be attributed to failure to make full use of the recommended technology. Only 28.1 percent of the farmers studied in Zone II used at least three-quarters of the recommended amounts of all three main inputs: nitrogen, phosphorus, and plants per hectare. Another 19.3 percent of the Zone II farmers applied at least three-quarters of the recommended rates of fertilizer, but used fewer plants than recommended. In Zone V, 56.9 percent of the farmers in the study used at least three-quarters of the recommended amounts of nitrogen, phosphorus and plant density, with an additional 37.2 percent falling short only in the use of the recommended plant density.

The data obtained in the weed-control experiments refuted the hypothesis that the maize technology recommended by the Project results in greater weed infestations than traditional technology. When the more intensive weed control measures of the new technology were used, the weed population at harvest time was lower than that obtained with traditional methods, and increases in maize production were proportionately greater.

A sixth approximation of the recommended production practices was developed in early 1973. The recommendations for several producing systems in Zone II are shown in Table 3.8, illustrating the type of information on production practices available to farmers in 1973.

TABLE 3.8. The seventh approximation of the recommended production practices for several producing systems in Zone II.

Producing system				Fertilizer (kg/ha) to apply at:						
Soil morphology	Planting date	Crop	Level of capital*	Planting $N - P_2O_5$	First cultivation N	Second cultivation N	Maize population density plants/ha	Maize variety	Bean population density plants/ha	Variety of beans or other crops
1. Deep soils of Popocatépetl.	Apr. 1- May 15	Maize	I	30 - 40	0	100	50,000	H-131	- -	- -
			II	0 - -	80	0	40,000	H-131	- -	- -
1.2. Free of pumice on the surface; less than 2350 m altitude.		Maize in orchards: a) 2 rows on each side of trees	I	30 - 40	0	50	40,000	H-131	- -	- -
		b) Other rows	I	30 - 40	0	100	50,000	H-131	- -	- -
	Apr. 25- May 15	Maize-bean association	I	30 - 40	0	120	40,000	native	60,000	native
			II	30 - 0	0	60	30,000	native	45,000	native
		Bunch beans	I	60 - 60	0	0	- -	- -	120,000	native
	May16- June 15	Maize and maize in orchards	I	30 - 40	70	0	40,000	native	- -	- -
	May 16- June 15	Maize-bean association	I	30 - 40	120	0	40,000	native	60,000	native
			II	30 - 30	60	0	30,000	native	45,000	native
	May 16- June 30	Bunch beans	I	60 - 60	0	0	- -	- -	120,000	native
	July 1- July 15	Bunch beans	I	30 - 30	0	0	- -	- -	90,000	native
	June 16- July 15	Oats	I	40 - 40	Use 90 kg of seed per hectare					Cuauhtémoc
		Barley	I	30 - 30	Use 60 kg of seed per hectare					Apizaco
		Horse beans	I	40 - 40	Plant density of 60,000 pts/ha					INIA 15001

* Recommendation I presupposes the availability to the farmer of unlimited capital for maize production; recommendation II presupposes limited capital of one-half to two-thirds that required for the more costly recommendation.

AN EVALUATION OF THE AGRONOMIC RESEARCH PROGRAM

This section seeks to evaluate the results of agronomic research in terms of impact on maize yields, on net incomes of farmers, and on the risks farmers take with input investments for maize production. A major difficulty in making such an evaluation stems from the fact that increases in production and net income are generated by many interacting factors (production credit, distribution of inputs, markets, input cost: product price ratios, etc.), and not by improved technology alone. Nevertheless, it seems reasonable to examine the influence of project recommendations by comparing increases in maize yields and net income—and changes in risk as well—that can be expected if farmers adopt each of several production technologies presently available.

According to the 1967 survey, 69.3 percent of the farmers applied fertilizers to their maize plantings that year. The production technology of those farmers (on the average) consisted of approximately 50 kg/ha N, 25 kg/ha P_2O_5, 10 kg/ha K_2O (potassium), 25,000 plants/ha, a local variety and a planting date ranging from 0 to 75 days before the beginning of the rainy season. Each of these production factors showed variation across the Project area, probably in response to the diversity of local producing conditions. Unfortunately, the 1967 survey was not designed to collect such information on the local production technology. Thus, the average production technology of farmers is used here to represent the traditional technology, allowing flexibility only for the local variety and the planting date. The inflexibility of the fertilizer treatment and the population density assumptions is very probably biased against the traditional technology in these comparisons. However, the assumption that all farmers fertilized their maize should be a bias favoring the traditional technology, since only 69.3 percent of farmers applied fertilizer to their maize plantings in 1967.

A maize technology, recommended by the National Agricultural Research Institute (INIA), was available to the Puebla farmers in 1967. It consisted of 80 kg/ha N, 40 kg/ha P_2C_5, 40,000 plants/ha, the hybrid H-28, and planting as soon as the rains began. This recommendation applied to the entire Project area.

The INIA technology was modified in two ways to facilitate the comparison of technologies: (a) the recommendation to plant at the beginning of the rainy season was changed to "plant early (late March, April, early May) in producing systems with adequate residual moisture." (It is known, *a posteriori,* that early plantings of maize produce higher yields. It was assumed that, once active promotion of the INIA technology was underway, the Project staff would recognize this fact and quickly change the recommended date of planting). (b) the recommendation to plant H-28 was discarded. This change was made because native varieties (not H-28) were planted in most of the experiments whose results were used to compare the different technologies. It was thought that this change would introduce little bias against the INIA technology, since local varieties compare favorably with H-28 in their yielding ability (see Chapter 4).

As indicated previously, the results obtained in the experiments conducted in 1967 were used to develop a new recommendation for maize, referred to here as the second approximation to the maize production technology. Experimental results obtained in subsequent years were used to develop a third, fourth, fifth, and sixth approximation. The sixth approximation, available at the beginning of 1972, included recommendations for 16 maize-producing systems. As shown in Table 3.9, these systems differed in soil morphology, previous crop, elevation above sea level, or planting date. Alternative recommendations for two levels of capital investment were available for each of the 16 systems. The recommendation for the lower level of capital, referred to here as the limited capital recommendation, was selected rather intuitively; however, it corresponds closely to the factor combination that maximizes the rate of return on capital.

The 16 pairs of recommendations, together with their variable costs expressed in tons of maize grain per hectare,

TABLE 3.9. The 16 producing systems recognized in the Project area since 1972.

1.1.1	Deep soils of Popocatépetl; elevations between 2,100 and 2,350 meters above sea level; plantings before May 15.
1.1.2	Deep soils of Popocatépetl; elevations between 2,100 and 2,350 meters above sea level; plantings between May 16 and June 15.
1.2	Deep soils of Popocatépetl; elevations between 2,351 and 2,800 meters above sea level; plantings before April 30.
2.1.1	Pumiceous soils of Popocatépetl; elevations between 2,100 and 2,350 meters above sea level; plantings before May 15.
2.1.2	Pumiceous soils of Popocatépetl; elevations between 2,100 and 2,350 meters above sea level; plantings between May 16 and June 15.
2.2	Pumiceous soils of Popocatépetl; elevations between 2,351 and 2,800 meters above sea level; plantings before April 30.
3	Soils of La Malinche; plantings before April 5.
4	Heavy soils of Zone V; plantings at the start of the rainy season.
5.1.1	Soils with a compacted horizon; plantings made in March and April.
5.1.2	Soils with a compacted horizon; plantings made in May.
5.1.3	Soils with a compacted horizon; plantings made in June.
6.1.1	Sodic-like soils; plantings made in March and April.
6.1.2	Sodic-like soils; plantings made in May.
6.1.3	Sodic-like soils; plantings made in June.
7.1	Soils with a high water table; plantings immediately after the turning of alfalfa stubble; plantings before April 15.
7.2	Soils with a high water table or any irrigated soil; one or more years after the turning of alfalfa stubble; plantings before April 15.

are shown in Table 3.10. Variable costs were calculated on the assumption that the farming operation was a mixed enterprise. Hired labor was included as a cost, but labor by family members was not included. For the calculations in Table 3.10, it was assumed that hired labor included: one-third of the labor at planting and the first fertilization; one-half of the labor at the second cultivation and second fertilization; three-fourths of the labor at harvest time; and one-third of the labor for shelling. The expense of this labor was included as a variable cost.

Several aspects of the unlimited capital technologies shown in Table 3.10 may be noted: (a) the recommended rates of nitrogen vary from 0 to 150 kg/ha with an average of 108 kg/ha, weighted according to the area planted to maize (Table 3.11). The zero value corresponds to maize planted immediately after turning under alfalfa stubble, in soils with a high water table. The 150 kg/ha value is for maize plantings in both irrigated soils and soils with a high water table, where one or more years have elapsed since the incorporation of alfalfa stubble; (b) the recommended rates of phosphorus vary from 0 to 60 kg/ha P_2O_5, with a weighted average of 32 kg/ha; (c) the recommended plant densities vary from 30,000 to 60,000 plants/ha, with a weighted average of 48,530 plants/ha; and (d) the variable costs of these production formulas vary from 0.02 to 1.46 tons/ha of maize, with a weighted average of 0.98 ton/ha.

The variable costs of the limited capital technologies vary from 0.02 to 0.92 ton/ha of maize, with a weighted average of 0.64 ton/ha. The variable costs of the traditional and INIA technologies are 0.54 and 0.82 ton/ha of maize, respectively.

Three assumptions were made in comparing the limited capital and unlimited capital technologies of the Project with the traditional and INIA technologies: (a) the averages of the experimental yields obtained from 1967 through 1972 are reasonable approximations of the average yields that will be obtained in the future; (b) experimental yields, when reduced by 20 percent, are reasonable approximations to commercial yields; and (c) the areas planted to maize, costs of inputs and prices of grain and stover will not soon change appreciably.

The basic data for comparing technologies were produced in 125 field experiments, which included fertilization, plant density, and date of planting variables, conducted on farmers' fields from 1967 to 1972. These experiments sampled, with varying degrees of intensity, the 16 producing systems listed in Table 3.9. The areas plants to maize in each of these systems were estimated from survey data and the soils map shown in Figure 1.2. The number of experiments conducted in each producing system, areas planted in maize, and average commercial yields estimated for the four technologies are shown in Table 3.11.

Table 3.12 shows the distribution of the 125 experiments among years and among five producing systems. The three largest systems (1.1.1, 2.1.1, and 3) were sampled quite adequately in each of the six years. The remaining 13 systems, taken individually, were much less adequately sampled, either because the number of experiments was small or the distribution among years was inadequate. As a group, however, the 13 systems were sampled quite satisfactorily. The four production technologies are compared here for producing systems 1.1.1, 2.1.1, and 3; the combined 13 systems; and the entire Project area.

Net increases in maize yields, ΔM, were calculated for the different technologies and producing systems according to the formula:

$$\Delta M = Y - C - T$$

where Y is the estimated commercial yield, C is the variable cost associated with a given technology above the cost of the check expressed in ton/ha maize and T is the yield of the check treatment (no fertilizer, 30,000 plants/ha). As shown in Table 3.13, estimated average net increases using the traditional, INIA, limited capital, and unlimited capital technologies were 0.74, 1.05, 1.12, and 1.44 tons/ha of maize, respectively.

TABLE 3.10. The production technologies, together with their costs, recommended for 16 producing systems in the Project area since 1972.

	Recommended technology * for:		Cost of the technology** in tons of maize in the field	
Producing system	Limited capital	Unlimited capital	Limited capital	Unlimited capital
1.1.1	80- 0-40,000	130-40-50,000	0.60	1.19
1.1.2	60-20-30,000	100-40-40,000	0.55	0.96
1.2	80-40-40,000	130-60-50,000	0.82	1.30
2.1.1	80-40-40,000	130-60-50,000	0.82	1.30
2.1.2	60-20-30,000	100-50-50,000	0.55	1.03
2.2	80-40-40,000	130-60-50,000	0.82	1.30
3	80- 0-40,000	100- 0-50,000	0.60	0.75
4	80- 0-40,000	100- 0-50,000	0.60	0.75
5.1.1	80-30-40,000	130-50-50,000	0.76	1.25
5.1.2	80-30-40,000	110-50-50,000	0.86	1.10
5.1.3	60-20-30,000	80-40-40,000	0.55	0.82
6.1.1	80-30-40,000	110-50-50,000	0.76	1.10
6.1.2	60-20-30,000	80-40-40,000	0.55	0.90
6.1.3	60-20-30,000	60-20-30,000	0.55	0.55
7.1	0- 0-60,000	0- 0-60,000	0.02	0.02
7.2	100-30-50,000	150-60-60,000	0.92	1.46
Averages +	75-15-38,260	108-32-48,280	0.64	0.98

* The three values refer to kilograms per hectare of nitrogen, kilograms per hectare of P_2O_5 (phosphorus) and plants per hectare, respectively.

** This is the total cost of fertilizer (price, transport, application, insurance, interest) expressed in terms of grain, after costs of harvesting, shelling, sacking, and transport have been discounted. The cost of the traditional and INIA technologies are equivalent to 0.54 and 0.82 tons of grain, respectively. If these values and the values in the table are multiplied by $54.80, the costs of the technologies in U.S. dollars are obtained. This value for maize in the field is based on a price of U.S. $72 per ton for maize with 14% moisture, placed at a warehouse of the National Marketing Agency.

\+ Weighted according to the areas planted to maize (See Table 3.11).

TABLE 3.11. The number of experiments conducted in 16 producing systems in the Puebla area, areas planted in maize, and estimated commercial yields* using various production technologies.

Producing system	No. of expts.	Area planted in maize ha	Check**	Traditional technology +	INIA technology +	Project technologies Limited capital	Unlimited capital
1.1.1	27	10586	0.52	2.05	2.86	2.63	3.80
1.1.2.	16	7072	0.38	1.34	1.88	1.49	2.08
1.2	1	1019	0.68	1.88	2.37	2.37	3.36
2.1.1	18	8874	0.79	2.15	2.82	2.82	3.87
2.1.2	8	3642	0.20	1.09	1.54	1.20	1.97
2.2	4	1852	0.48	1.89	2.54	2.54	3.45
3	24	22739	1.00	2.56	3.29	3.20	3.64
4	7	2078	1.15	2.04	2.49	2.41	2.71
5.1.1	3	2817	0.88	2.12	2.66	2.58	3.66
5.1.2	5	4355	1.44	2.28	2.65	2.59	3.01
5.1.3	5	5636	0.15	1.26	1.61	1.35	1.62
6.1.1	1	1281	0.34	0.66	1.64	1.60	2.21
6.1.2	1	1963	0.52	1.43	1.88	1.55	1.88
6.1.3	3	2540	0.44	0.90	1.08	1.04	1.04
7.1	1	893	4.00	4.00	4.96	5.41	5.41
7.2	2	2653	1.60	3.62	4.12	4.42	5.14
Total	125	80000					
Average++			0.78	2.05	2.67	2.54	3.19

* The commercial yield was estimated as 80% of the yield obtained experimentally; expressed as tons per hectare of grain with 14% moisture.

** No fertilizer; 30,000 plants per hectare.

\+ Traditional technology; 50 kg/ha of nitrogen, 25 kg/ha of P_2O_5 (phosphorus), 10 kg/ha of K_2O(potassium) and 25,000 plants per hectare.

INIA technology: 80 kg/ha of nitrogen, 40 kg/ha of P_2O_5, and 40,000 plants per hectare.

++ Weighted according to the areas planted in each producing system.

Estimated net increases for one producing system (6.1.3) were: −0.08, −0.18, 0.05, and 0.05 ton/ha, respectively, for the traditional, INIA, limited capital, and unlimited capital technologies. These values were calculated from data obtained in two experiments conducted in 1969 and one in 1970. The implication of these figures could be that it is irrational to plant maize in this system. However, due to the limited amount of data available (and to the probability that farmers' experiences, covering a much longer period of time than that studied experimentally, has demonstrated the profitability of maize production), a tentative recommendation was made of 60 kg/ha N, 20 kg/ha P_2O_5), and 30,000 plants/ha.

TABLE 3.12. Distribution of the experiments conducted in the Project area among years and among five producing systems.

Producing system	Area planted in maize ha	1967	1968	1969	1970	1971	1972	Total
1.1.1	10,586	9	7	2	3	4	2	27
2.1.1	8,874	3	3	3	3	4	2	18
3	22,739	2	0	6	8	4	4	24
13 remaining systems	37,801	8	3	7	19	15	4	56
all 16 systems	80,000	22	13	18	33	27	12	125

Table 3.14 shows the variable costs, net increases, risks, and "adequacy indices" for the four technologies used in systems 1.1.1, 2.1.1, and 3; the combined 13 systems; and the total Project area. As used here, risk is defined arbitrarily in two ways: (a) as the standardized probability that the net increase in maize yield will be 0.5 ton/ha or less, and (b) as the standardized probability that the net increase in maize yield will be 0 ton/ha or less. In the remainder of this chapter, the first criterion of risk will be expressed as R (0.5) and the second criterion as R (0).

One of the definitions of risk – as a net increase of 0.5 ton/ha or less of grain – was based on 1970 survey data indicating that an average family consumed 1,546 kg/year of maize for food, and had an average area of 2.27 ha of maize. Thus from each hectare in maize, an average of 0.68 ton of grain was needed to feed the family. In this definition of risk, it was assumed that most of the yield obtained with the check treatment would be used to cover the fixed costs of production, and that 0.5 ton/ha to feed the family would have to come from net increase in yield.

TABLE 3.13. Estimated net increases in tons of maize per hectare, ΔM^*, using four production technologies in 16 producing systems.

Producing system	Traditional	INIA	Limited capital	Unlimited capital
1.1.1	0.99	1.52	1.51	2.10
1.1.2	0.42	0.65	0.56	0.78
1.2	0.67	0.88	0.88	1.37
2.1.1	0.82	1.19	1.19	1.77
2.1.2	0.35	0.47	0.50	0.67
2.2	0.87	1.24	1.24	1.67
3	1.05	1.45	1.61	1.92
4	0.38	0.59	0.80	0.93
5.1.1	0.73	0.96	0.96	1.53
5.1.2	0.30	0.39	0.39	0.47
5.1.3	0.57	0.64	0.65	0.65
6.1.1	–0.22	0.49	0.50	0.77
6.1.2	0.38	0.55	0.49	0.55
6.1.3	–0.08	–0.18	0.05	0.05
7.1	–0.54	0.14	1.39	1.39
7.2	1.48	1.70	1.91	2.08
Overall**	0.74	1.05	1.12	1.44

* The commercial yield obtained with a given technology, less the check yield, less the variable costs associated with the use of the technology. The commercial yield is estimated to be 80% of the experimental yield, expressed as grain with 14% moisture.

** Averages weighted according to the areas planted in maize.

The value $\Delta M \leq 0$ is used in the alternative definition of risk, to examine the case in which the value of the increase in maize yield is equal to or less than the variable costs of production. Information is available in Table 3.14 to calculate risk using net increase values other than 0.5 or 0 ton/ha.

In the calculation of risk there is an implicit assumption that the net increase values belong to a population with a normal distribution. This hypothesis was tested for traditional technology used in the entire Project area, and was not rejected.

For the five systems in Table 3.14, calculations were made of the mean squares of the net increase values associated with the following: (a) years, with a degrees of freedom; (b) total, with $n-1$ degrees of freedom; and (c) residuals (sites confounded with the interaction sites x years), with $n-1-a$ degrees of freedom. In 18 of the 20 cases (four technologies x five systems), the mean square associated with years was larger than that associated with sites plus the site x years interaction. In nine cases, the difference was not significant; in six it was significant at the 5 percent level; and in three cases it was significant at the 1 percent level. The mean square associated with years was selected as the estimator of the variance of the net increase values. This quantity appears in Table 3.14 as $s^2_{\Delta M}$.

The values of risk presented in Table 3.14 were obtained from a tabulation of areas corresponding to a normal population with a mean of 0 and a variance of 1. To use this table, the values 0.5 and 0 were standardized for each technology and producing system by subtracting the value of ΔM and dividing by the appropriate standard deviation, $s^2_{\Delta M}$.

The use of traditional technology in producing system 1.1.1 gave an average net increase in maize production of 0.99 ton/ha, with a risk represented by the number 0.213 for R(0.5) and the number 0.054 for R(0) (see Table 3.14). This level of risk indicates that the net increase will be 0.5 ton/ha or less in four years out of 20, with one year having zero or negative net increase. The estimated net increase using traditional technology in system 1.1.1 was more than that for system 2.1.1, and similar to that for system 3. The level of risk in using traditional technology in systems 2.1.1 and 3 indicates that net increases of 0.5 ton/ha or less can be expected in 6 years out of 20. In two of the six years, the net increase will be zero or negative for system 2.1.1, whereas in system 3, three of the six years will have a zero or negative net increase of yield. These three systems are the most productive in the Project area and account for 53 percent of the area planted to maize.

The use of traditional technology in the 13 remaining systems gave an average net increase of 0.44 ton/ha with a risk represented by the numbers 0.547 for R(0.5) and 0.195 for R(0). That is, in 11 out of every 20 years a net increase of 0.5 ton/ha or less can be expected; 4 of these 11 years will show a zero or negative net increase.

The average net increase for the whole area using traditional technology was 0.73 ton/ha with a risk represented by the numbers 0.399 for R(0.5) and 0.206 for R(0).

This means that in 8 out of 20 years the net increase of yield will be 0.5 ton/ha or less; whereas in 4 of the 8 years the net increase will be zero or negative.

Average net increases in production per unit of cost, expressed as kilograms of maize, are shown in Table 3.14 as values of Δ M/C. These values were 1.83, 1.52 and 1.94 for traditional technology in systems 1.1.1, 2.1.1, and 3; 0.81 for the combined 13 systems; and 1.35 for the total area.

When compared with the traditional technology, in all five individual and aggregated producing systems, the INIA, limited capital, and unlimited capital technologies produced higher net increases in maize yields and lower risks, with two exceptions. These two exceptions were in relation to risk and not in relation to net increases in yields. When risk is defined as R(0), the limited capital technology becomes slightly riskier in system 1.1.1 than the traditional technology: 0.065 versus 0.054. With the same definition of risk, the unlimited capital technology is slightly riskier than the traditional technology in the total area (aggregated 16 producing systems).

The unlimited capital technology was superior to the INIA technology when compared in terms of net increase in yield, or as risk defined as the probability that the net increase in yield be equal to 0.5 ton/ha or less, R (0.5), in the five individual and aggregated producing systems. Using the same criteria, the unlimited capital technology was also better than the limited capital technology in systems 1.1.1, 2.1.1, and 3; whereas in the remaining systems, net increases in yield were larger with the unlimited capital tech-

TABLE 3.14. Variable costs, net increases, risks, and "adequacy indices" for four production technologies used in several individual or aggregated producing systems.

Individual or aggregated producing system*	Technology	Variable cost of technology C (ton/ha)	Net increase Δ M** (ton/ha)	$\frac{\Delta M}{C}$	$s^2_{\Delta M}$ +	Risk, R++ P(ΔM ≤ 0.5)	P(ΔM ≤ 0)	Adequacy indices ° of the technologies Ia °°	Ib	IIa	IIb	IIIa	IIIb
1.1.1 (27)	Traditional	0.54	0.99	1.83	0.3804	0.213	0.054	1.00	1.00	1.00	1.00	0.66	0.91
	INIA	0.82	1.52	1.85	0.6932	0.110	0.034	2.97	2.45	1.96	1.61	1.26	1.44
	Limited Capital	0.60	1.51	2.52	0.996[illegible]	0.156	0.065	2.09	1.25	1.88	1.13	1.18	1.37
	Unlimited Capital	1.19	2.10	1.76	1.0200	0.056	0.019	8.01	6.06	3.63	2.75	1.91	2.04
2.1.1 (18)	Traditional	0.54	0.82	1.52	0.3749	0.304	0.090	1.00	1.00	1.00	1.00	0.41	0.70
	INIA	0.82	1.19	1.45	0.3948	0.136	0.029	3.25	4.45	2.14	2.93	0.92	1.13
	Limited Capital	0.82	1.19	1.45	0.3948	0.136	0.029	3.25	4.45	2.14	2.93	0.92	1.13
	Unlimited Capital	1.30	1.77	1.36	1.1453	0.117	0.049	5.60	3.93	2.33	1.63	1.41	1.62
3 (24)	Traditional	0.54	1.05	1.94	1.0190	0.295	0.149	1.00	1.00	1.00	1.00	0.58	0.81
	INIA	0.82	1.45	1.77	1.7421	0.236	0.136	1.73	1.52	1.14	1.00	0.92	1.14
	Limited Capital	0.60	1.61	2.68	2.0559	0.219	0.131	2.06	1.74	1.85	1.57	1.13	1.32
	Unlimited Capital	0.75	1.92	2.56	3.3232	0.218	0.147	2.47	1.86	1.78	1.34	1.34	1.53
13 systems (56) (aggegated)	Traditional	0.54	0.44	0.81	0.2644	0.547	0.195	1.00	1.00	1.00	1.00	-0.10	0.25
	INIA	0.82	0.63	0.77	0.1399	0.364	0.046	2.15	6.00	1.42	3.95	0.10	0.56
	Limited Capital	0.64	0.68	1.06	0.0918	0.277	0.013	3.05	23.93	2.57	20.10	0.31	0.67
	Unlimited Capital	0.99	0.86	0.87	0.5159	0.308	0.115	3.47	3.31	1.89	1.81	0.29	0.65
Overall (125)	Traditional	0.54	0.73'	1.35	0.8021	0.399	0.206	1.00	1.00	1.00	1.00	0.22	0.47
	INIA	0.82	1.06'	1.29	1.2194	0.306	0.168	1.89	1.78	1.24	1.17	0.48	0.74
	Limited Capital	0.64	1.11'	1.73	1.3319	0.298	0.168	2.03	1.86	1.71	1.56	0.59	0.82
	Unlimited Capital	0.98	1.46'	1.49	3.4542	0.303	0.215	2.63	1.92	1.45	1.06	0.72	0.94

* The number of experiments conducted in each system is given in parenthesis.

** The commercial yield obtained with a given technology, less the check yield, less the variable costs associated with the use of the technology.

\+ $s^2_{\Delta M}$ is the estimator of the variance among years, of the net increase values (5 degrees of freedom).

++ The standardized probability of obtaining a net increase equal or smaller than 0.5 and 0 ton/ha.

° $I = \frac{\Delta M_i}{\Delta M_t} \div \frac{R_i}{R_t}$; $II = I \div \frac{C_i}{C_t}$; $III = \Delta M(1 - R) \cdot CR$

The index i, indicates INIA, limited capital and unlimited capital technologies; t indicates traditional technology.

°° Ia, IIa, and IIIa refer to the case when R=P(ΔM ≤ 0.5 ton/ha); Ib, IIb and IIIb refer to the case when R=P(ΔM ≤ 0 ton/ha).

' Unweighted averages.

nology, but risk was also higher. Using R (0) as the criterion of risk, the unlimited capital technology was riskier than both the limited capital and the INIA technologies in all instances, except in system 1.1.1.

For the five individual and aggregated producing systems, the unlimited capital technology produced net increases in yield about twice those obtained with the traditional technology. The risk using unlimited capital technology was 26 to 76 percent of that using traditional technology with R (0.5), and was 35 to 104 percent of that using traditional technology with R (0). The variable costs of the unlimited capital technology were 1.39 to 2.41 times greater than those of the traditional technology.

Net increases in yield using the limited capital technology and the INIA technology were equal for systems 1.1.1 and 2.1.1. The risk using the two technologies was the same in system 2.1.1, but was higher by 42 percent when using R (0.5) and by 91 percent when using R (0), for the limited capital technology in system 1.1.1 (13 percent of the area). Variable cost of the limited capital technology was 27 percent lower than that of the INIA technology in the same system. Compared to the INIA technology in system 3 (29 percent of the area), the limited capital technology had a variable cost that was 27 percent less, a net increase in yield 11 percent higher, and a lower risk factor that was less by 7 percent using R (0.5), and less by 4 percent using R (0). The same comparison of technologies for the aggregated 13 systems (47 percent of the area) shows a variable cost for the limited capital technology that was 22 percent less, a net increase in yield that was 8 percent higher and a risk factor that was 24 percent lower using R(0.5) and 72 percent lower using R(0).

Average net increases in production per unit of cost, $\Delta M/C$, were higher using the limited capital, as compared to the traditional technology in four of the five systems. This was true in spite of the higher cost of the limited capital technology. The INIA technology was superior to the traditional technology in net increase per unit of cost only in system 1.1.1. The unlimited capital technology was superior to the traditional technology, using the net increase per unit of cost as a measure of efficiency, in 76 percent of the area (system 3 and the combined 13 systems).

The "adequacy indices" in Table 3.14 provide additional criteria for comparing the four technologies. Index Ia provides a measure of the relative net increase in yield per unit of risk for R (0.5), and Ib provides a similar measure for R (0), using traditional technology as a base. According to Index Ia, the unlimited capital technology in system 1.1.1 is eight times better than the traditional technology. Indices Ia and Ib, however, do not take into account the differences in variable costs associated with distinct technologies. Indices IIa and IIb do incorporate this concept, and, for system 1.1.1, Index IIa shows that the relative net

TABLE 3.15. Comparison of four technologies, assuming that each was used in the production of 80,000 hectares of maize.

	Traditional	INIA	Limited capital	Unlimited capital
Average yield (ton/ha)	2.05	2.67	2.54	3.19
Total production of grain (tons)	164 211	213 311	203 366	254 844
Average net increase (ton/ha of grain)*	0.74	1.05	1.12	1.44
Total net increase in grain (tons)	59 204	84 244	89 769	114 821
Total net increase in stover (tons)**	75 457	93 119	86 270	109 245
Value of net increase, ΔP^{+}	$3,666,928	$5,138,048	$5,402,432	$6,903,960
Fertilizers used:				
Ammonium sulphate (tons)	20 000	32 000	29 823	43 003
Simple superphosphate (tons)	9 756	15 609	6 067	12 775
Potassium chloride (tons)	1 333	0	0	0
Total cost of fertilizers, F^{++}	$2,353,584	$3,550,704	$2,787,552	$4,267,176
Δ P/F ratio	1.56	1.45	1.94	1.62

* The increase is the commercial yield, less the check yield, less the variable costs expressed in ton/ha of grain. The average net increase is weighted according to the area in each producing system.

** Net increase in stover is the yield with a given technology, less the check yield.

\+ Value of the grain in the field was $54.80/ton; value of stover in the field was $5.60/ton. These are market prices less costs associated with harvesting and marketing.

++ The cost of fertilizer was the market price plus costs of transport, application, interest on loan, and crop insurance.

increase in yield per unit of risk, adjusted for differences in variable costs, is 3.63 times greater for unlimited capital technology than for traditional technology. Index IIIa is a measure of the outcome of a game in which the farmer plays to win Δ M and has a probability of 1−R (0.5) of doing so, but also has a probability, R (0.5), of losing C.

A comparison will next be made of the impact of the four technologies on production, net increases, and fertilizer consumption, assuming each technology were to be used on the 80,000 ha of land normally devoted to maize production in the Project area. The data needed for this comparison are shown in Table 3.15. Estimated total production with the four technologies varies from 164,211 to 254,844 tons/year; the value of net increase varies from $3,666,928 to $6,903,960; and the cost of fertilizers varies from $2,353,584 to $4,267,176.

Compared with the traditional technology, the INIA technology would require a 51 percent larger investment in fertilizers and would produce 30 percent more maize with a net increase worth 40 percent more. That is, using the INIA technology, farmers could invest $1,197,120 more in fertilizers and gain an additional $1,471,120. Each additional dollar spent on fertilizers would yield a profit of $1.23. Globally, each dollar invested in fertilizers using the traditional and INIA technologies produces a gain of $1.56 and $1.45, respectively.

The limited capital technology would require an 18 percent larger investment in fertilizers than would the traditional technology; would produce 24 percent more maize, and would yield a net increase worth 47 percent more. Using the limited capital technology, farmers would invest $433,968 more in fertilizers than with the traditional technology, and would gain an additional $1,735,504. Thus, each additional dollar spent on fertilizers with the limited capital technology would give a profit or $4.00. In a global sense, each dollar invested in fertilizers using the limited capital technology would yield a profit of $1.94 compared to $1.56 in the case of the traditional technology.

The unlimited capital technology compared with the traditional, would require an 81 percent larger investment in fertilizers, produce 55 percent more maize, and yield a profit worth 88 percent more. Farmers would invest $1,913,592 more in fertilizers with the unlimited capital technology as compared to the traditional, but could gain $3,237,032 more. In this case, each additional dollar spent on fertilizers would yield a profit of $1.69.

4 MAIZE VARIETY IMPROVEMENT

INTRODUCTION

Prior to the Puebla Project, it was known that Chalqueño and Cónico were the predominant races of maize in the region. The Mexican Agricultural Research Institute (INIA) had done some varietal testing, and two hybrids (H-28 and H-129) were recommended for the area. A limited survey in the fall of 1966 indicated, however, that most farmers were growing native varieties. This finding was confirmed by a farm survey in early 1968 which revealed that, although 15 percent of the farmers had used hybrid maize on at least one occasion, less than 1 percent of the farmers had grown hybrids in 1967.

It seemed reasonable to expect varieties that yield more, particularly in unfavorable years, would be readily accepted by farmers and would represent an economical way to increase production. Thus, maize improvement research became an integral part of the Puebla Project. The research objective was to quickly develop improved varieties that would yield more than the available hybrids and native varieties, and that would compare favorably in terms of grain type, lodging, earliness, and disease resistance.

STRATEGY OF GENETIC IMPROVEMENT

The maize improvement program consisted of the following activities:

(a) The collection of information from farmers throughout the Project area to establish farmer preferences as to grain type, earliness, and other morphological characteristics.

(b) The collection of outstanding native varieties in the area. It was expected that some of these might be useful for immediate distribution, and many would be valuable as breeding materials.

(c) The testing of promising local varieties and exotic materials at representative sites throughout the area. Initially these varietal trials were to identify outstanding genotypes, both for immediate use and as breeding materials, and subsequently to compare the performance of existing and newly produced materials.

(d) The development of cryptic double-cross ($S_1 \times S_1$) hybrids and S_1 x double-cross hybrids. The decision to use this breeding method was based on experience in other areas indicating that it should be possible to develop a hybrid by the third year of the Project that would outyield the parental varieties by 25 to 30 percent. This timetable was dependent on growing two crops per year, through winter plantings at lower altitudes. Since the proposed life of the project was only 5 years, it was necessary to have improved materials available by the end of the third year, if they were to significantly influence production within this time period.

(e) The development of open-pollinated varieties through mass selection. This method was chosen on the basis of research experience suggesting that increase in yield could be expected, varying from 4 to 10 percent per year. In addition, since farmers would cooperate in the selection, they would have improved seed available immediately and could continue to attain better yielding materials through their own efforts after the Project ended.

Varietal trials were carried out each year at several locations, to compare the performance of native varieties, improved varieties and hybrids, and experimental materials.

PROGRAM AND RESULTS

As information was collected from farmers, it became evident that length of the growing season was a major concern of farmers in deciding which variety to plant. A majority of plantings are made in late March, April, and early May, in soils that conserve sufficient moisture from the previous rainy season. Farmers use late-maturing varieties for these early plantings. Early-maturing varieties make up the remainder of the maize planted in late May and June after the rains begin.

Farmers find a wide range of kernel colors—white, yellow, red, blue, and mixes—acceptable for home consumption. For the market, however, whites and yellows are preferred, since local buyers sometimes discriminate against reds and blues.

Overall, the maize improvement program has emphasized the production of high-yielding varieties, that are resistant to diseases and lodging, for both early and late plantings.

Production of Hybrids

During the summer of 1967, several local varieties were examined, and the variety Pinto Salvatori was chosen as germplasm for the production of cryptic double-cross hybrids. Five hundred crosses of selected plants were made and the second ears of each of the 1,000 parental plants were self-pollinated. Because of problems in obtaining sufficient seed of the cross, as well as the self-pollinations, the program realized only 94 complete sets.

During the winter of 1967-1968, topcrosses were made at the experiment station of the National Seed Production Company near Tepalcingo, Morelos, by crossing H-28 and S_1 lines of several varieties that were outstanding in the summer varietal trials. Individual plants of the variety were selfed at the same time they were crossed with 10 to 15 plants of H-28.

The 94 cryptic double-crosses from the variety Pinto Salvatori and 68 topcrosses from the winter program were yield-tested in 1968 at four locations in the Puebla area. Eleven of the cryptic double-crosses and eight of the topcrosses to H-28 yielded significantly more than did the best commercial hybrids.

The S_1 parents of the five best cryptic hybrids were planted for increase and to obtain more seed of the crosses at the Tepalcingo station during the winter of 1968-1969. Also, these 10 parental lines were arbitrarily divided into two groups to form two composites (A and B). The cross between these two composites was made in detasseling blocks and seed was produced for semi-commercial testing in the Puebla area.

Comp A x Comp B, together with the five best topcrosses to H-28 and other promising materials, was tested at three locations in the Puebla area during the summer of 1969. Selected farmers were given small lots of Comp A x Comp B for comparison against their local varieties. The results with Comp A x Comp B were not up to expectations.

During the summer of 1970, Comp A x Comp B was included in varietal tests at 16 locations and was planted on a semi-commercial scale at a few sites. From the results obtained in 1969 and 1970, it was evident that Comp A x Comp B was not superior to the parental variety, and it was decided not to promote the use of Comp A x Comp B in the Puebla area.

The five outstanding cryptic hybrids, the five best topcrosses to H-28, and Comp A x Comp B, were continued in the varietal trials in 1971 and 1972. The relative yields, days to flowering, and lodging percentages of these hybrids and other promising materials, are given in Table 4.1. Several conclusions can be drawn from these data: (a) compared to the parental variety Pinto Salvatori, Comp A x Comp B yields slightly less, has a slightly longer growing season, and has the same tendency to lodge; (b) four of the cryptic hybrids outyield Pinto Salvatori by 5 to 11 percent (two of these, 113 and 246, lodge less and have about the same growing season as the parental variety); and (c) the five topcrosses with H-28 yield from 2 to 7 percent more than H-28 (topcross 257 yields 7 percent more and flowers in 3 days less than H-28).

Production of Varieties

Observation nurseries, including 41 composites of earlier collections from the Puebla area and 18 other promising materials, were planted at two locations in the summer of 1967. The relative performance of the several entries provided guidance to select those materials to be used in the genetic improvement program. Two composites were formed at Tepalcingo during the following winter: (a) an early composite by intercrossing Puebla groups 10, 11, 26, and 30; Chapalote x Cónico; Chalqueño x Cónico; Harinoso de Ocho x Cónico; Colorado Salvatori; and H-28; and (b) a late composite by intercrossing Puebla groups 33, 44, and 49; Batán E-CIV; Hidalgo 8 M-CI; Pinto Salvatori; and Blanco Salvatori.

During the summer of 1968, mass selection blocks were planted and carried through the first cycle of selection with the early and late composites. The first cycle of mass selection in an opaque-2 composite was also conducted. The opaque-2 composite was formed by mixing seed that carried the opaque-2 gene from Mexico group 10, Hidalgo 8, Pinto Salvatori, and Blanco Rubín.

The mass selection blocks were fertilized each year according to the recommendations of the Project. Plant densities of 24,000 plants/ha were used in 1968, 1969, and 1970. Densities were changed to 50,000 plants/ha in 1971 as a result of a study at Chapingo indicating that the plant density in mass selection blocks should be similar to that in commercial plantings.

Mass selection with the early composite was done at four locations in 1968, five locations in 1969, and one location in 1970. Work with this composite was discontinued in 1971 when it became clear that it was not sufficiently early for late May and June plantings in the Puebla area.

TABLE 4.1. Relative yields, days to flowering (50% of tassels showing), and lodging percentages of selected maize varieties and hybrids studied in the area of the Puebla Project.

Material	Number of experiments	Number of Repts.	Relative Yield *	Days to flowering	Lodging %
H-28	84	228	100.0	95	4
Colorado Salvatori	26	88	97.5	91	10
Rojo Salvatori	45	96	85.4	87	7
Pinto Salvatori	84	228	103.2	97	13
H-129	82	224	102.6	106	7
H-129 (before Apr. 21)	30	78	106.9	—	—
H-129 (after Apr. 20)	52	146	100.0	—	—
H-127	27	92	93.1	101	4
H-125	23	84	102.2	102	4
H-131	19	56	119.5	106	7
CDC 358	14	40	112.7	102	12
CDC 275	14	40	108.7	100	13
CDC 246	14	40	110.6	95	9
CDC 205	14	40	101.7	101	17
CDC 113	14	40	114.1	97	9
Comp A x Comp B	28	86	102.4	100	13
H-28 x Pue gpo 44-309	15	44	105.0	97	5
H-28 x Colorado - 292	15	44	102.2	89	6
H-28 x Colorado - 257	15	44	107.2	92	6
H-28 x Colorado - 276	15	44	102.2	91	3
H-28 x Pue gpo 44 - 333	15	44	105.1	90	3
Comp 1T SMP	12	36	103.2	100	13
Comp 1500	35	92	97.2	100	15
Local variety	24	64	90.3	92	12

* Average yield expressed as a percentage of H-28 (average yield of H-28 at 84 sites = 5.47 ton/ha of grain with 14% moisture).

Mass selection with the opaque-2 composite was realized at one location in each of the years from 1968 to 1971. Mass selection with the late composite was carried out at 22 sites during the years 1968-1972, an average of 4.4 sites/year. CIMMYT decided in 1972 to discontinue the mass selection work, as well as other breeding activities. This decision was based on the assumption that maize breeding activities could not be conducted successfully on farmers' fields.

The late composite was included in varietal trials in 1970, 1971, and 1972; average yields of the late composite in 1972 before mass selection and after the fourth cycle were 6.14 and 6.38 tons/ha, respectively. Apparently, four cycles of selection produced little or no improvement in the late composite. Also, as seen in Table 4.1, the late composite, Comp 1T SMP, yields the same as Pinto Salvatori, is slightly later, and has the same tendency to lodge.

In 1972, the opaque-2 composite, after four cycles of selection, was compared with seven INIA opaques, three CIMMYT opaques, and three normal hybrids. The opaque-2 composite of the Project produced 4 percent more opaque grain than the best INIA material and 16 percent more than the best CIMMYT material. However, it still yielded well below the hybrids with normal grain (85 percent of H-129 and 70 percent of H-131).

Evaluation of Materials

A total of 163 varietal trials was done in the Project area during the period 1967-1972. These trials included farmers' varieties from the Puebla area and similar regions; improved varieties and hybrids; and experimental materials from CIMMYT, INIA, the Graduate College at Chapingo, and the breeding program of the Puebla Project. Separate trials were conducted for late materials, early materials, and opaques. These trials were conducted at population and fertilization levels similar to the unlimited capital recommendations of the Project.

The relative yields of 21 of the most outstanding materials are shown in Table 4.1, along with days to flowering and lodging percentages. Pinto Salvatori is an outstanding native variety and should be used more widely in the area. In yielding ability it compares favorably with H-129 and H-125 and is superior to H-28 and H-127. A recently released INIA hybrid, H-131, is the highest-yielding material studied, outyielding Pinto Salvatori and H-129 by about 16 percent. It should be recommended for March and April plantings in the Project area.

The varietal evaluations summarized in Table 4.1 include a small sample of local varieties (only the eight collected in the spring of 1967). A second collection of native varieties was made in the winter of 1970-1971, including 216 from Puebla, 20 from Tlaxcala, 9 from Hidalgo, and 4 from Veracruz. These were divided into early and late materials and included in evaluation trials in 1971 and 1972.

In Table 4.2, the average yields and days to flowering of 20 of the best late native varieties are compared with Pinto Salvatori, H-129, and H-131. Pinto Salvatori and H-131 outyielded all the native varieties. On the other hand, the native varieties outyielded H-129. These findings indicate that many of the native varieties in Puebla compare favorably in yielding ability to the best improved materials presently available. (It should be remembered that when a local variety and a hybrid yield almost equally and are similar in other respects, the local variety is preferred because of the expense and other problems associated with the production and distribution of hybrid seed.)

In Table 4.3, the average yields and days to flowering of 18 of the best early native varieties are compared with the hybrids H-35E, H-30, and H-28. The materials are arranged in order of earliness to facilitate the comparison of varieties with similar growing seasons. Both H-30 and the experimental hybrid, H-35E, outyielded all native varieties that had a similar number of days to flowering. H-30 flowered five days earlier than H-28 and should be useful for May and early June plantings. H-35E flowered a week before H-30 and might be suitable for mid-June plantings.

EVALUATION OF THE RESEARCH PROGRAM

The maize improvement program did not meet its goal of developing higher-yielding materials and putting them into commerical production by the seventh year of Project operation. Two of the best cryptic hybrids outyielded the best materials available in 1967 by about 10 percent. However, as the parental lines of these crosses yielded poorly and lodged badly, it was not feasible to produce these hybrids commercially. The Comp A x Comp B, formed from the parental lines of the five best cryptic hybrids, could have been produced at low cost, but unfortunately it did not retain the high yielding capacity of the single crosses.

TABLE 4.2. Average yields and days to flowering of late maturing local varieties and introduced hybrids. The values are averages for seven experiments carried out in 1971 and 1972.

Material	Yield of grain with 14% moisture ton/ha.	Days to flowering
Pinto Salvatori	5.52	107
Pue. 26	5.45	118
Pue. 66	5.36	107
Pue. 41	5.30	118
Pue. 77	5.30	111
Pue. 108	5.28	108
Pue. 79	5.28	114
Pue. 27	5.21	120
Pue. 67	5.21	106
Pue. 119	5.17	111
Tlax. 145	5.17	113
Pue. 69	5.17	113
Pue. 45	5.12	113
Pue. 4	5.10	105
Pue. 62	5.08	106
Pue. 2	5.07	104
Pue. 59	5.07	108
Pue. 10	5.06	105
Pue. 116	5.06	108
Pue. 141	5.04	112
Pue. 36	5.04	107
H-131	5.60	120
H-129	4.65	121

TABLE 4.3. Average yields and days to flowering of early maturing local varieties and introduced hybrids. The values are averages for four experiments carried out in 1971 and 1972.

Material	Yield of grain with 14%moisture ton/ha.	Days to flowering
Tlax. 237	2.27	82
Pue. 178	2.35	83
Pue. 153	2.59	84
Pue. 217	2.49	85
H-35E	3.14	86
Pue. 139	2.70	86
Pue. 175	2.52	87
Pue. 214	2.68	87
Pue. 184	2.75	88
Pue. 183	2.80	88
Pue. 53	2.83	88
Pue. 216	2.90	89
Pue. 159	3.08	89
Pue. 210	2.78	90
Pue. 200	3.26	90
Pue. 86	2.88	91
Pue. 91	2.92	91
Pue. 29	3.07	91
Pue. 195	3.01	92
H-30	3.82	93
H-28	3.60	98

Four years of mass selection in the late composite at a total of 19 sites produced little or no improvement in yielding ability. This result is not in accord with the experiences of many maize breeders and possibly was influenced by the following considerations: (a) the plant density in the selection blocks in 1968, 1969, and 1970 was only about half that used in commercial plantings; there is some evidence that plants that are outstanding at low densities are not necessarily superior at high densities; (b) there were difficulties at many sites in achieving complete isolation of the selection block, because the adjoining plantings could not be controlled; this may have resulted in the introduction of undesirable germplasm into the composite; and (c) the land chosen for some of the selection blocks was quite variable; this made it difficult to select only those plants that were genetically superior.

The major contribution of the maize improvement program has been in determining the usefulness of local and introduced materials for early and late plantings in the area. Pinto Salvatori is an outstanding local variety that should be used more widely for plantings in March, April, and early May. H-131 yields about 16 percent more than Pinto Salvatori and is recommended for March and April plantings. H-30 is superior to local varieties for late May and early June plantings. H-35E shows promise for mid-June plantings. In general, the maize improvement work demonstrated that many local varieties are high-yielding when production conditions are favorable.

Maize improvement experience in the Puebla Project indicates that the development of improved varieties for a regional program can perhaps best be achieved in a cooperative effort with a nearby research center. The crop improvement component of the regional program would have the responsibility of collecting the information that is necessary to clearly define the characteristics of the improved varieties needed by farmers. The regional program would assist in the collection of local genetic materials that might be useful in producing such improved varieties. It would determine the major conditions used for crop production in the area and conduct evaluation trials at sites located so as to adequately sample these conditions.

The crop improvement program at a neighboring research center would have the responsibility for selecting the materials and methods for producing improved varieties. It would supervise all breeding activities, both in the regional program and at the research center. The selfing, crossing, and selection of materials might be done either at the research center or at appropriate locations in the Project area. The selection of plants tolerant to moisture stress, for example, might best be made at appropriate sites in the Project area. The most experienced personnel available should participate in any step involving a subjective evaluation of materials.

Field demonstrations were held at harvest time, to show farmers how yield and net income were increased by using the new technology. Here the net returns from using the recommended number of bags of fertilizer are being discussed with the farmers.

5 TECHNICAL ASSISTANCE TO FARMERS

INTRODUCTION

Technical assistance to Puebla Project farmers began in early 1968, when new maize recommendations were developed based on the 1967 research results and complementary data. This new maize technology brought several changes for its users, including (a) higher investment in fertilizers—the new fertilizer recommendation in 1968 cost about 130 percent more than the average fertilizer treatment used in 1967 by the 70 percent of the farmers who fertilized their maize; (b) purchase of individual fertilizer materials instead of a formula, and the mixing of the materials at home; (c) application of a part of the fertilizers at planting time and the remainder at the second cultivation, instead of applying all the fertilizer at the first cultivation; (d) use of higher plant densities—50,000 plants/ha—instead of the 15,000 to 25,000 used earlier; and (e) control of weeds, with more complete and timely methods, plus control of the rose chafer at flowering time when necessary.

Although these changes were largely quantitative, they did imply wide-reaching changes in farm management and farming practices for the Pueblan farm families.

The central aim of the technical assistance program was to provide every possible assistance necessary to enable the farmers to use the new technology effectively. Technical assistance agents sought rapid adoption of Project recommendations by concentrating on: (a) providing the farmers with information about the Project, including how the new recommendations were developed and the several components of the new recommendations; (b) assisting the farmers in obtaining credit and in arranging for fertilizers; (c) instructing the farmers in the most efficient ways to use the recommendations; and (d) collecting information from the farmers about obstacles limiting their use of agricultural services in the area, transmitting the information to the members of the Project team and to representatives of service agencies, and assisting in finding ways to overcome the difficulties.

PROJECT PROGRAM: 1968

Location of the High-yield Plots

A demonstration program was planned for 1968 so that the farmers could have a first-hand look at the advantages of the new maize technology. Plans were made to locate "high-yield" plots throughout the western three-quarters of the Project area. Initially, the plans called for the customary procedure used for locating demonstrations; that is, choosing of highly accessible locations with good soils, where the largest possible number of farmers could see the plots. This approach implied that the fields should be located first, and the owners then convinced to participate. However, the experience obtained by the evaluation team in early 1968 indicated a change in strategy. The team encountered negative attitudes and, in some cases, hostility among many farmers; thus plans were revamped to work through the existing power structure in each community.

The political administrative unit in the Puebla area is the ***municipio*** or county, each of which has a principal village and several ancillary population units or communities. The municipal president and other municipal authorities live in the principal village with auxiliary authorities, responsible to the municipal president, residing in each of the communities.

As a first measure, the Project staff began to contact the municipal presidents and explain the Project and its goals. These initial visits provided a brief description of the Project, using the report prepared for the first annual meeting, a map showing the locations of the experiments conducted in 1967, and a list of the cooperating farmers. This basic information was attached to an official letter of presentation signed by the General Agent of the Ministry of Agriculture, the State Director of Agriculture, and the coordinator of the Project. The letter explained the responsibilities of the municipal authorities and the important role they would play in developing the Project.

The presidents were asked to arrange general meetings of all the municipal authorities, so that full information could be provided about the Project and the work plans for 1968. Such meetings were held in all but one of the municipios in the western three-fourths of the Project area.

During the first meeting with the municipal authorities, careful explanation was made of what the Project could provide and how the farmers might cooperate. At the completion of each meeting, the participants were asked which farmers in the locality might be interested in the Project. The authorities usually asked for time to return to their villages to explain the Project and find out who might be interested. In a few cases, the local authority himself was ready to participate and to initiate Project work in his village.

The next step was to schedule a series of meeting with farmers in the villages where authorities had expressed some interest. The local authorities took the initiative in organizing the meetings and inviting the farmers. At these meetings, Project technicians explained the Project and suggested how the farmers might participate by using the new recommendations in a part of their maize plantings. A total of 31 such meetings were held.

The farmers learned that they would have to provide the fertilizers and labor, and the Project technicians would assist in the field operations to assure that the recommendations were used correctly. For those who did not have money to purchase the fertilizers, help was offered in obtaining credit from a private or official agency. After all aspects involved in using Project recommendations had been explained in detail and discussed at great length, a small group of farmers gradually took the initiative. These farmers generally had two characteristics: they were (a) responsible workers of their land with a desire to progress, and (b) persons whose moral character and influence were amply recognized in the community.

In some communities, many farmers wished to participate; in such cases, the final selection of participants was made by visiting the possible sites. Generally, no less than two and no more than five sites were selected in each community, but in a few cases there were more than five. There were 25 sites around one village, and eight sites at another, due principally to the enthusiasm of the farmers and the fact that the village land was very extensive. There were only two instances where farmers were accepted and later withdrew; these withdrawals were due to objections of the wives, principally because the husband was planning to obtain fertilizer on credit and they objected to going in debt.

Credit

A total of 141 high-yield plots, varying in size from 0.25 to 1.0 ha, were established by 103 farmers. Each farmer was given information about the availability of credit, the interest rate, and what the role of crop insurance could be in reducing risks from natural causes.

In 1968, 60 percent of the farmers who participated were financed by Agronomos Unidos, a private fertilizer distributor. An additional 20 percent of the credit was provided by the Agricultural Bank of the South, and 20 percent of the plantings were self-financed by the farmers. Credit was provided at an interest rate of 1-1/2 percent/month. The credit was extended for 9 months, sufficient time to cover the long growing season and allow the farmer to harvest and sell enough maize to repay the loan.

The letters of credit which the farmers signed on receiving the fertilizers were prepared in two ways: most of them showed only the amount of the loan and the rate of interest; a few indicated the total amount of the loan plus interest. In those cases where the interest was calculated in the original loan agreement, and the farmer paid before the 9 months were up, he received a cash refund for interest corresponding to the difference between 9 months and the actual loan time. This turned out to be an agreeable surprise with good will resulting for the distributor who provided the credit.

In contrast, there was occasional friction when the farmer arrived to pay his loan with the understanding that only the principal was to be paid as indicated in the letter of credit. In such cases, when the interest was calculated, the farmer often did not have enough money on hand to make payment. One such farmer considered the interest a fraud. Bad feelings often occurred, even among those farmers who understood that the credit terms were very favorable compared to local lenders and had simply forgotten to calculate the interest. Because of these experiences, it was decided that the total amount of the loan, principal plus interest, should be stated in the letter of credit, whenever possible.

Crop Insurance

After the plantings had been made, the crop insurance agency insured them. This was an experimental operation for the insurance agency, because their usual procedure was to insure plantings of only 5 ha or more. The plots financed by Agronomos Unidos varied from 0.25 to 1.0 ha, and at the outset it was difficult for the insurance agency to include them. However, the risk aspects of rainfed plantings were of special interest to the Project, and the participation of the crop insurance agency was ultimately arranged. The insurance agency made the necessary inspections of the plantings, and discarded 14 plots that were considered unacceptable. The remainder were fully insured. According to the yield levels obtained at the end of 1968, the insurance agency had no indemnifiable losses whatsoever due to hail, drought, wind, frost, and other risks covered by the program. There were reductions in yield due to these causes, but none that would require payment under the insurance regulations. The maximum coverage was for a value equivalent to 1.1 tons/ha grain.

Planting and Care of the High-yield Plots

The high-yield plots were planted on dates decided upon by the farmer cooperators. The plantings were used as demonstrations, and the neighboring farmers were invited to watch the procedures. In some cases, the cooperating farmer made the fertilizer mixture several days before planting; in others, the mixing was part of the demonstration.

The farmers were shown how and when to apply the mixture so that the fertilizer would be evenly distributed at the bottom of the furrow. A convenient local measure was found for calibrating the fertilizer distribution a 1-liter oil can. When this can was filled to about one finger below the top and distributed over 20 meters, the appropriate amount of the mixture was applied. For rapid measuring, a 20-meter wire was used to locate stakes at 20-meter intervals along the row.

The program to promote farmer use of the new maize technology was initiated in 1968, with 103 farmers participating with 141 high-yield plots. Eighty percent of these farmers were provided credit by a fertilizer distributor and an official bank. Here farmers are seen signing loan agreements.

The traditional planting rate for maize required a full step distance between hills; however, the new planting rate was demonstrated in terms of a distance between hills of about one-half step. The higher population required learning a new rhythm of planting–inserting the shovel, opening and covering twice as many holes per hectare.

To assure an optimum population density, the farmers, at first, were taught to overplant and then thin to the desired 50,000 plants/ha. In this way, the population could be assured in spite of soil insects, inadequate germination, and other factors. However, the fertilizer applied at planting time caused vigorous early growth. When told that it was time to thin the plants, the farmers frequently replied: "Here I have one of the most beautiful plantings of maize that I have ever grown, and you want me to pull out some of the plants." To them, pulling of the superfluous plants was a destructive act. As a result, before the planting season was far advanced, it was decided to reduce the planting rate and eliminate the thinning operation.

The technicians kept in contact with the high-yield plots throughout the growing season. As the plantings were completed, attention was given to weed control, and where necessary, to control of the rose chafer. Demonstrations for neighboring farmers were held at the second cultivation when the second fertilizer application was made. The visiting farmers learned which fertilizer to apply, and how much, as well as how to keep fertilizer out of the bud to avoid damaging plants.

Result Demonstrations

Local demonstrations were held just prior to harvest at 15 of the high-yield plots, and neighbors and farmers from adjoining communities were invited via local sound equipment, printed circulars, and posters. Attendance ranged from 11 to 75 farmers.

The demonstration consisted of three parts: (a) the technical assistance agent's explanation of the Puebla Project, (b) the cooperating farmer's report of the practices used in the high-yield plot, and (c) open discussion led by the farmer and technician. An interesting aspect of the discussion was the obviously greater self-confidence felt by the visiting farmers when raising questions and making comments to the farmer-demonstrator.

Two regional demonstrations also were held just before harvest at strategic locations where both a high-yield plot and an experiment could be seen. Farmers with high-yield plots in each locality were asked to organize the event. In meetings with these farmers to plan the demonstration, two aspects were noted: (a) the farmers lacked confidence in their ability to plan and carry out a demonstration, and (b) they thought that no one would attend. They felt that the technical assistance agents should make the decisions. The technicians, however, encouraged the farmers and insisted that the farmers handle the arrangements.

The organizational approach which evolved was to name a committee of the most enthusiastic farmers with the formal title: Committee for Organizing the Agricultural Field Day. The committee took charge of: (a) inviting the authorities, both of the federal and state governments, (b) inviting the neighbors, (c) naming a person to receive each of the groups as they arrived from the different communities, and (d) naming members to look after the smooth functioning of the demonstration to assure that there would be an atmosphere of hospitality.

The technical assistance agents invited farmers from other parts of the Project area, using personal contact, a poster, a printed circular, plus personal invitations to all farmers with high-yield plots. General attendance was good at both events.

Through organization of the events, the farmers gained experiences of lasting value, plus confidence in their ability to conduct demonstrations of this type. Attendance was greater than they had imagined possible, and often included farmers from the more distant villages.

Other demonstrations were held throughout the growing season for representatives of various Mexican state and national institutions, including the Secretary of Agriculture, the Governor of Puebla, state directors of agriculture, directors of the official banks, and many other professionals interested in the Project. There were also numerous visitors from Latin America, Europe, and the United States.

Printed Matter and Audio-visual Aids

In meetings with farmers it was impressive to see that even those who were barely literate took notes on the recommendations on scraps of paper. Mimeographed and printed materials were prepared to ensure accurate recording of the information.

At the end of 1968, a pamphlet was published with Project recommendations for increasing maize yields entitled: "Would You Like to Increase Your Maize Yields? ". The text was minimal and essential data were shown in illustrations. Thus, farmers attending a meeting could first hear the recommendations and then take home a folder containing the same information.

During the 1968 maize growing season, farmers in the region also played a central role in the filming of a 16-mm color movie for use in promotional activities in subsequent years, entitled: "Would You Like to Increase Your Maize Harvest? ".

Pamphlets were prepared with the information farmers needed to use project recommendations correctly. The text was kept to a minimum, and the essential data were presented in illustrations.

A 16 mm. film in color entitled "Would You Like to Increase Your Maize Harvest? " was produced in 1968. The film has been very useful in demonstrating to farmers exactly how to obtain higher yields of maize. It also serves as an attraction to bring farmers together to discuss common problems of credit and input availability.

PROJECT PROGRAM: 1969

The Project began its 1969 program on an optimistic note: successful contact had been made with the social network of the farming community in 1968, additional research results were available, finances had been obtained to expand the technical team of the Project, and the banks and fertilizer distributors were ready to expand credit to make fertilizer more readily available. Thus, the Project team and service institutions decided to attempt to extend the use of the improved technology to a total of 10,000 ha operated by about 5,000 farmers.

As in 1968, promotional activities were concentrated in the western three-fourths of the Project area. This region was divided into four zones (Fig. 1.2) and a technical assistance agent was given responsibility for each zone.

Organizing Groups

If the four technical assistance agents were to provide guidance to 5,000 farmers in using the new maize recommendations, it was clearly necessary that the farmers be organized into groups. Beginning in early 1969, the technical assistance agents began to hold meetings in the villages to promote the formation of groups. These meetings were often organized through farmers who had participated with high-yield plots in 1968. Many of these farmers were already aware of the advantages of working together in groups, particularly because of past problems encountered in arranging for the transportation of small quantities of fertilizer at a reasonable price.

A typical meeting began with an explanation of the Project and presentation of the results obtained by farmers with high-yield plots in 1968, followed by a showing of the locally produced color film: "Would You Like to Increase Your Maize Harvest? ". The film was extremely useful in demonstrating how higher yields could be obtained. It lent credibility to the recommendations by its careful documentation of 1968 successes, using local names and places. About halfway through the film, projection was stopped and questions encouraged. During this intermission, a mimeographed map of the region was distributed, that gave recommendations for each community. Thus, each farmer could identify his own land, and, on the back of the sheet, find the specific fertilizer recommendation. The movie was shown 71 times in 59 villages, with a total attendance of 4,570 in 1969.

After the advantages of the new maize technology had been amply discussed at a meeting, and farmers had expressed an interest in using it, the technical assistance agent suggested that the farmers consider forming a group. He stressed that organization would permit: (a) ready access to information about the recommendations and assistance in using them correctly, and (b) easier arrangements for credit and fertilizers.

Two or more meetings and lengthy discussions were sometimes necessary before the farmers were convinced of the advantages of organized action and decided to form a group. Once the group was formed, the members elected a representative and proceeded to discuss operational procedures, acceptance of new members, credit arrangements, etc. The technical assistance agents devoted most of their time to the formation of the groups, and to assisting them in increasing their membership, learning about the Project recommendations, and arranging for credit and fertilizers.

During the cropping season interchanges among farmer groups were organized. A representative of the host group welcomed the visitors and explained how the farmers in his group were trying to improve their crop production. Then the hosts and visitors made a walking tour of high-yield plots in the immediate vicinity.

Radio Usage

A radio program about the Project was initiated in March 1969 over a local radio station that transmits to all the Project area. The program was aired Sunday mornings from 7:30 - 8:00—one of the most convenient hours for farmers, according to data collected by the evaluation team. Individuals and groups were advised of the program via a printed flyer, which included the topics, the radio station, the hour, and the date. Farmers were encouraged to tell their neighbors of the program.

The radio program content included recommendations and news notes about happenings of the moment. For example, farmers were notified that fertilizers had arrived at some location, that farmers who had their land prepared should mix their fertilizers to be ready for planting, that they should mix simple super phosphate and ammonium sulphate in certain proportions and take certain precautions to preserve it. Basically, the program attempted to provide specific technical information about matters of current interest to the farmers. In addition, popular local music was included.

Supervision of the High-yield Plots

In all villages with one or more organized groups, a demonstration was held at planting time to instruct the farmers in the new fertilization and planting techniques. As in 1968, the technical assistant agent first showed the farmers how to distribute the fertilizer and place the seed. Then all farmers attending were invited to participate in the planting.

During the 60 days or so following the emergence of the maize, the technical assistance agents accompanied the members of the organized groups on field inspections of their high-yield plots. The technicians called attention to any deficiencies in the way the fertilizer had been applied, distance between hills of maize, weed control, etc., explaining how such factors could reduce yields. It was emphasized that greater care in employing the new technology would enable the farmers to realize higher yields and net income.

Interchanges Among Farmer Groups

During the summer of 1969, after most of the maize had received the last cultivation, the technical assistance agents began to talk with several outstanding groups of farmers about organizing a tour of their high-yield plots and inviting farmers from other parts of the area to attend. In general, the idea was received with enthusiasm, and 11 of the groups proceeded to organize such events.

The members of the group hosting the tour decided when it should be held, how it should be organized, and which groups should be invited to attend. The technical assistance agent provided information about possible groups to invite, and assisted in delivering invitations to the groups.

The local farmers received the visitors at a convenient location for beginning the tour. The representative of the host group welcomed the visitors and explained what the farmers in his group were doing to increase their maize production. Hosts and visitors then made a walking tour of several high-yield plots in the immediate vicinity. The owner of each plot gave a short explanation of the practices used in his planting. The other farmers were encouraged to ask questions, offer suggestions, and tell about their own maize production practices. As opportunities arose, the technical assistance agent would point out examples of the correct or deficient use of the several components of the improved maize technology. Refreshments were usually served by the hosts at the close of the tour.

These events, referred to locally as interchanges among farmer groups, provided opportunities for farmers from different parts of the Project area to exchange experiences and ideas about a wide range of subjects. While the tour was in progress, the conversation was usually centered on questions related to the production of maize, beans, and other crops. During meals and afterward, the farmers frequently broke up into small groups and discussed a variety of farming and non-farming activities. A total of 570 farmers from 35 villages participated in these interchanges in 1969.

Result Demonstrations

The success of the demonstrations held just prior to harvest in 1968 prompted planning in early 1969 to hold six regional demonstrations in the fall of 1969. Convenient locations were selected for the demonstrations, and several agronomic trials plus a high-yield plot were installed at each site.

As in 1968, the local farmers organized the field days. Project technicians explained the experiments and the importance of the findings. The owner of the high-yield plot described the practices that he used and gave a benefit: cost analysis of the operation. Approximately 1,200 farmers attended the six regional demonstrations.

Beginning in 1969, technical assistance agents have encouraged farmers to organize into groups. This has facilitated the flow of information on technology to the farmers and has enabled them to arrange for credit and fertilizers more easily.

PROJECT PROGRAM: 1970

The technical assistance program was expanded in 1970 to encompass the entire Project area. A fifth technical assistance agent was assigned the responsibility for Zone V, the eastern part of the area.

The first 3 months of 1970 were devoted to an intensive campaign to increase the number of farmers using Project recommendations. Meetings were held in the villages throughout the area to explain Project recommendations and show the results obtained in previous years by farmers using the new technology. Again the Project-produced film, "Would You Like to Increase Your Maize Harvest? ", was very useful in this promotional effort and was projected in 116 communities with an attendance of 9,900 farmers.

The farmers were encouraged to form new groups and to increase the membership of groups already functioning. Groups with very large membership were urged to divide into smaller groups, to simplify administration and allow more farmers an opportunity to participate in a leadership capacity. Operating procedures of the different credit agencies were explained to the groups and they were assisted in presenting their requests for credit and in complying with the requisites of the agencies.

During the maize planting and vegetative development periods, the technical assistance agents concentrated on helping the farmers to use the new technology correctly. As in previous years, demonstrations were held at planting time and field inspections of high-yield plots were made during the early part of the growing season. During the summer, there were eight interchanges among groups of farmers, with 610 farmers from 62 communities participating.

Farmer meetings continued to be held throughout the year to provide information on crop production practices, the organization of groups, the operating procedures of service agencies, etc. Approximately 500 farmers were assisted in attending a field day at the Chapingo research center of the National Agricultural Research Institute. Regional demonstrations were held in Zones II, III, IV, and V just prior to the maize harvest, with an attendance of 1,300 farmers.

By early 1970, the technical assistance agents were beginning to receive requests from the farmers for information and guidance in improving their production practices for crops other than maize, particularly from farmers who had used Project recommendations the previous season. One of the first requests was for recommendations for the production of beans. This request was transmitted to the rest of the Project team and research on bean production was initiated by Project technicians during the 1970 season.

PROJECT PROGRAM: 1971

In 1971, the technical assistance program continued to promote greater use of Project recommendations by the farmers, to instruct the farmers in the correct use of the new technology, to assist organized groups in arranging for credit and fertilizers, and to provide information on a variety of subjects of interest to the farmers. Project recommendations were available in 1971 not only for maize, but also for bush beans and alternative crops for maize (in years when plantings are delayed until late June or early July).

A total of 192 meetings were held in 91 villages with 3,686 farmers in attendance in 1971. Movies were projected for 1,576 farmers in 60 villages. Ninety-three demonstrations of planting techniques were held in 75 communities, with 1,389 farmers participating. Interchanges among groups of farmers were arranged in two communities. Radio programs were broadcast each Sunday morning at 7:30 from March through December.

During 1971, the farmers continued to bring pressure on the technical assistance agents to assist them with a variety of production activities. These requests were communicated to the other members of the Project team. Most of the requests, however, required resources and expertise not available in the Puebla Project, which was funded primarily to increase maize production. Thus, the technical assistance agents began to search for ways to mobilize resources from outside the Puebla Project for use in responding to the farmers' requests.

As a result of this work, short courses on the management of fruit orchards were organized and were attended by about 1,000 farmers in six communities. These courses were presented by specialists in fruit culture, employed by the Mexican state and federal governments. Specialists of the National Extension Service also participated in demonstrations held at four locations to show how small trench silos are used to preserve maize stover in the form of silage.

PROJECT PROGRAM: 1972

As in past years, the technical assistance program focused primary attention on increasing the efficient use of Project recommendations. A total of 382 meetings were held in 107 villages, attended by 7,875 farmers. There were 187 demonstrations of the planting techniques and the second application of nitrogen in 86 communities, with 3,121 farmers participating. Eight regional demonstrations were held just prior to the maize harvest, with a total attendance of 771.

The technical assistance agents continued to assist farmers with other activities whenever possible. Farmers in 58 villages were assisted in constructing 119 trench silos for the preservation of about 1,280 tons of stover. Farmers in Zones I and II were given help in arranging for 3,600 fruit trees and establishing 12 ha of orchards. Women in a few villages were aided in acquiring sewing machines and organizing sewing centers.

PROJECT PROGRAM: 1973

The technical assistance program in 1973 continued to center attention on increasing the adoption of Project recommendations. These recommendations, however, now included packages of production practices for the maize-pole bean association as a result of research conducted during 1970-1972. The results obtained in many experiments had shown conclusively that net income from the association could be significantly greater than from either maize or beans grown alone. Thus, the technical assistance agents began to tell the farmers about the advantages of the new technology for the maize-bean association, encouraging them to try the association on a part of their land.

Several obstacles were encountered, however, that limited farmer use of the new recommendations for the maize-bean association. The information that previously had been available to the service institutions recommended that maize and beans should be grown alone, rather than in association. Thus, the crop insurance agency was not prepared to insure the association, and the official credit banks could not authorize credit for farmers who wished to grow it. The Project team arranged discussions with the representatives of the banks and crop insurance agency, and explained the research results that clearly demonstrated the advantages of the association. The representatives of the institutions were convinced by the research findings, and modified their operating procedures so that credit and insurance were available for the maize-bean association.

A further difficulty was presented by the farmers themselves. They objected to the recommended plant density for beans–60,000 plants/ha–contending that it was too high and would result in severe lodging before maturity. The Project agronomists agreed that their research data on plant density for beans was not conclusive and that it should be investigated further. They insisted, however, that farmers use the recommended seeding rate for beans in at least a few rows of their maize-bean associations.

Although these problems greatly reduced the effectiveness of the campaign promoting the new technology for the maize-bean association, it was possible to get farmers to use the new recommendations on small plots at many sites throughout the area.

Use of Agua Ammonia

A new source of fertilizer and credit became available in 1973 to farmers in the Puebla area who made use of Project recommendations for maize. Guanomex, the decentralized federal agency responsible for the production and distribution of chemical fertilizers, was interested in finding a way to make fertilizers available to small farmers at a lower cost. Guanomex decided that this objective could be achieved, using agua ammonia as the source of nitrogen. They offered to provide agua ammonia to farmers, on credit, along with the applicators, other equipment, and technical assistance required for its use. Ammonium phosphate, 18-46-0, also was made available for application at planting time to farmers who planned to apply phosphorus.

In 1973, Guanomex promoted the use of aqua ammonia by small farmers in the Puebla area. Although there are problems in the design of the applicator yet to be resolved, there is interest in this source or nitrogen, because of its lower cost.

The Puebla staff studied the proposal of Guanomex and decided that the potential advantages for the small farmers in Puebla of having this additional source of nitrogen available at a lower cost outweighed the risks involved in moving ahead with a technology that had not been tested locally.

Therefore, the technical assistance agents began meetings in early April to inform farmers of the availability of the new source of fertilizer and credit, and to explain that the cost of nitrogen in the form of agua ammonia was expected to be about 60 per cent of that of solid materials. They also described the characteristics of agua ammonia and the precautions to observe in its application, etc. Although many farmers were not convinced that agua ammonia was equal to the solid sources of nitrogen, they were attracted by the lower cost and seemed confident that it must be satisfactory, since the technical assistance agent was recommending it. More than 2,000 farmers signed up to use agua ammonia on some 5,000 ha of maize.

Guanomex made a horse-drawn applicator available in late April for testing in the Puebla area. It turned out to be almost impossible to handle the applicator in the field, because of its excessive weight and high center of gravity. The farmers were invited to offer suggestions on how to improve it. Several farmers agreed to assist in redesigning the applicator. Within a short time, a much lighter, better balanced, applicator was developed, although still not totally satisfactory.

It was late May before the redesigned applicators were available to the farmers, and the plant for the production of agua ammonia was in operation. By that time, most of the farmers who had signed up to use agua ammonia had found it necessary to arrange for solid materials in order to make the sidedressing application of nitrogen at the proper time. Guanomex had provided many of these farmers with urea and ammonium sulphate through two of its local distributors. In total, agua ammonia was used by about 250 farmers on approximately 500 ha.

More Effective Group Action

When Project technicians began to promote the organization of farmer groups in 1969, they expected that these groups would gradually develop into strong farmer organizations, with the capability of taking the leadership in finding solutions to many of their problems. By early 1972, such development had not occurred. Most farmers looked upon the groups solely as an instrument for obtaining credit and fertilizers. Once this was accomplished, they had little interest in meetings or other group activities until it was again time to arrange for credit.

As Project technicians and advisors explored ways of developing the effectiveness of the groups, they were acutely aware of their lack of experience in such work. Thus, arrangements were made for a sociologist with many years of experience in organizing small farmers in Mexico to devote a part of his time to providing technical assistance to Project staff.

A new strategy for working with the farmer organizations was not adopted until mid-1973. Each of the technical assistance agents then began to hold general meetings, inviting the members of the several groups in his zone. The technician presented the proposition that many problems prevented the farmers from improving their agricultural production, net income, and general welfare. He suggested that the farmers themselves could best resolve these problems. He pointed out that people like himself and representatives of the service agencies could help, but, in order for their help to be effective, the farmers would have to participate more actively in deciding what needed to be done and how to do it.

Several general meetings were held over a period of several weeks at which the farmers discussed the problems which they felt to be the greatest obstacles to progress. Gradually, they were able to define a small list of problems that were most pressing, and, of these, the one which they felt should receive top priority.

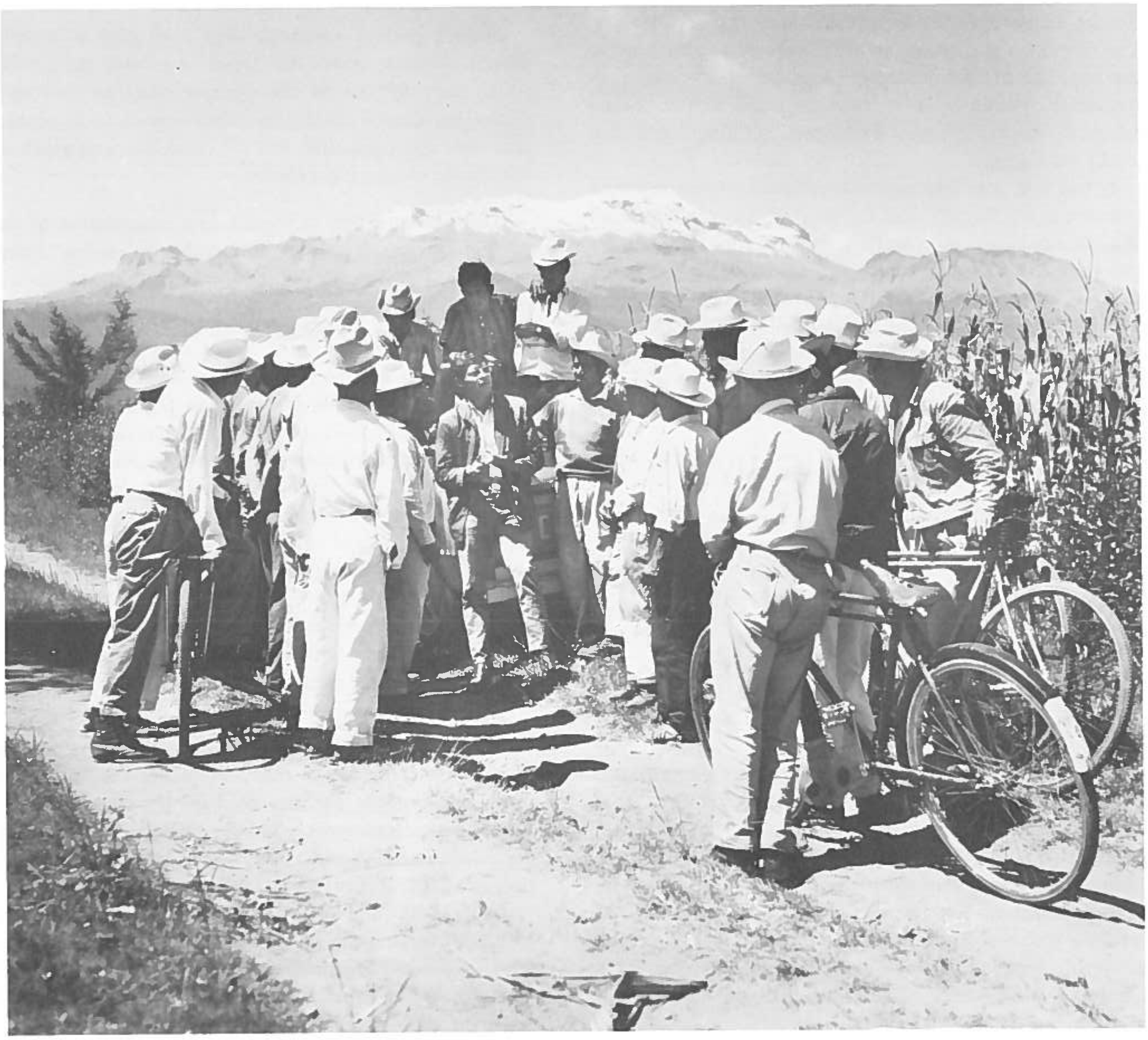
The next step was to form a new organization of those farmers interested in working together to resolve common problems, and, specifically, the problem they had given top priority. These new organizations are still in the process of development and consolidation.

The Union of Progressive Maize and Bean Farmers of Zone III is an example of these new farmer organizations. This organization held its first meeting in August 1973 and has been meeting regularly every two weeks. It decided to give top priority to finding means for members to obtain chicken manure at a lower cost. After a few weeks of study, the Union discovered that by eliminating the mark-ups by two middle men—the truck driver and the administrator of the chicken farm—the current price for manure (about $112/truck load) could be cut in half. The Union began negotiating directly with the owners of the chicken farms to obtain this better price.

Although the Union has made some progress in its efforts to make manure available to its members at a lower cost, it has encountered many obstacles. Its lack of legal status, for example, has prevented the Union from negotiating long-term contracts with the manure producers. It is expected that this problem can be resolved through legalization as a Civil Society.

In 1973, the Union had 95 members from nine villages, with a Governing Board composed of 18 farmers, who are the old group coordinators and their alternates from the nine villages. The affairs of the Union are administered by a president, secretary, and treasurer and their alternates.

Farmers in organized groups periodically hold meetings with the technical assistance agent. These meetings provide opportunities for the farmers to obtain information about production technology, credit, crop insurance, and other matters of interest to them.



6 ORGANIZATION OF THE FARMERS

INTRODUCTION

The new maize recommendation promoted in 1968 was used by 103 farmers located throughout most of the Project area. Their average yield was 3.98 ton/ha on a total of 76 ha. These results were extremely favorable, and it was decided that the new technology should be promoted as rapidly as possible among all farmers in the area.

In 1968, the technical assistance agents had worked directly with individual farmers. With an estimated 43,300 farm operators in the area and only four technical assistance agents and their assistants available in 1969, it was clearly necessary to find a way to work with groups of farmers, rather than individuals. In addition to facilitating the flow of information to and from farmers, organized groups of farmers could better: (a) arrange for credit, inputs, and other agricultural services; (b) encourage favorable change in the operating procedures of the service institutions; (c) secure more favorable prices in the purchasing of inputs and the marketing of produce; and (d) plan and conduct projects for community improvement.

A review of organizational experiences in other parts of Mexico and other countries with many kinds of farmer organizations, produced no particular organizational model that seemed appropriate for the farmers in Puebla. As a beginning, therefore, it seemed advisable to: (a) acquire as much information as possible about farmers' experiences with, and attitudes toward, group action; (b) provide farmers with information about the advantages of working together; and (c) assist farmers in organizing in the ways they felt most appropriate.

ORGANIZATION OF FARMERS PRIOR TO THE PUEBLA PROJECT

The political unit in the State of Puebla is the *municipio*, or county. It is governed by a council consisting of a president, secretary, and treasurer. The council is usually housed in a central building in the principal town in the *municipio*. Most of the legal and administrative actions affecting the citizens of the various communities in the *municipio* occur in that building, including: payment of property taxes, civil wedding ceremonies, regrestration of births and deaths, etc. Each village in the *municipio* has an auxiliary council with the responsibility for less important transactions. This type of organization was introduced by the Spaniards during the Colonia Era and has undergone few changes.

Many of the villages in Puebla are *ejidos*. These are communities of farmers who received land from the government as a result of the agrarian reform. (The title to the land remains with the *ejido*. The *ejidatario* retains use rights to land within the *ejido* without paying rent as long as he farms it, and at the time of his death may will these rights to a member of his/her immediate family.) The highest authority within the *ejido* is the *comisariado*, or executive committee. Its principal function is to represent the interest of the *ejidatarios* in their relationships with higher authorities and service institutions. A second function is to participate in political actions at the community level and, through the Agrarian Community League, at the regional and national levels. The *comisariado* consists of a president, secretary, treasurer, and vigilance committee.

Credit societies were functioning in several *ejidos* at the time of the 1967 survey. An *ejidal* credit society consists of those *ejidatarios* who wish to receive credit from the National Ejidal Credit Bank, an official credit agency formed with the express purpose of providing credit to the *ejidatarios*. The society is represented in its transactions with the Bank by a delegate. A vigilance committee is responsible for watching over transactions between the *ejidal* authorities and the Ejidal Bank and for seeing that the credit received by the *ejidatarios* is used for production purposes. The credit societies functioning in 1967 limited their action to arranging for credit; they were not involved in acquiring better information on crop production practices or other activities to increase net income from agricultural production.

Small landowners in at least two villages in the area had been organized in agricultural credit societies prior to 1967. These societies consisted of landowners who wished to obtain credit from another official bank, the National Agricultural Credit Bank. Neither of these societies was functioning at the time of the 1967 survey.

ACTION OF THE PUEBLA PROJECT IN THE ORGANIZATION OF FARMERS

To obtain a better understanding of farmers' attitudes toward organized group action and their previous experiences in trying to work together, the interviews in the 1967 survey asked the farmers specific questions about matters of organization. The majority of farmers interviewed showed no desire to belong to an organization. Few members of the community, even members of their own families, were considered worthy of their trust and confidence. Many of those interviewed declared that they preferred "to work alone," "not to depend on anyone," and that "each person should do whatever his means permit."

The farmers also expressed distrust of the motives of the Puebla Project. When told that the services of the technical assistance agents would be free, they replied that "no one ever came to the communities with the sole purpose of doing good." They felt that, in one way or another, they would have to pay for the assistance. Many farmers suspected that the Project was a scheme to expropriate their land to set up an industry, or to redistribute the land. Some farmers seemed to feel that the Project was the government's way of finding out how much each farmer owned, so their taxes could be raised. And there were farmers who declared that the interviewers must be Communists, because "only Communists go around in groups and talk about the necessity of organizing the poor."

Clearly, in the early stages of the Project's implementation, it would have been fruitless to talk to the farmers about the advantages of organizing groups or credit societies for participation in the action program. Thus, the new maize recommendation in 1968 was promoted among individual farmers on a voluntary basis.

Many of the farmers who participated in 1968 felt that the transportation of the fertilizers was both expensive and troublesome. If they chose to move the fertilizers by passenger buses, the sacks were often torn and the fertilizer spilled. If an individual farmer hired a truck to transport his fertilizer, it was costly to haul the small amounts. Farmers who purchased their fertilizers from local stores found the prices to be relatively high.

These experiences caused the farmers to discuss group action as means of lowering the costs of the fertilizers and of transporting them to the farm. The Project's technical assistance agents encouraged the farmers to fully explore advantages of organized action and to discuss it with their neighbors.

During the promotion stage for the 1969 growing season, the idea of organizing groups of farmers began to be accepted in many villages. The technical assistance agents pointed out that, in addition to being able to transport fertilizers at lower cost, organizing would make it easier for the farmers to secure credit and other services. It was also mentioned that they would be able to buy fertilizers at a lower price than could be obtained by individuals, after the members of a group had accumulated sufficient reserves of capital.

The promotional activities of the technical assistance agents in early 1969 led to the organization of 58 credit groups with 1,556 members (Table 6.1) to receive credit and fertilizers from a local fertilizer distributor, Agrónomos Unidos. The Agricultural Bank of the South participated in the organization of 55 groups with 542 farmers, and made credit available to them for maize production. The other official credit banks provided credit to enable their regular clients to use Project recommendations. As shown in Table 6.1, the National Ejidal Credit Bank authorized credit for 413 *ejidatarios* organized in 15 credit societies, and the National Agricultural Credit Bank financed 50 individual farmers.

The Impulsora de Puebla, the main fertilizer distributor in the State, participated indirectly in 1969 by providing financing and fertilizers to Agrónomos Unidos. The Impulsora continued its funding of Agrónomos Unidos in 1970 and, in addition, provided credit directly to 253 farmers in 21 groups. In 1971, the Impulsora absorbed the clients of Agrónomos Unidos and continued to provide credit to a similar number of farmers in 1972 and 1973.

The National Ejidal Credit Bank decided in 1970 to reactivate many credit societies in the Puebla area that had been suspended because a large proportion of their members had failed to repay their loans. Thus, the number of credit societies receiving credit in 1970 increased to 59, with 2,122 farmer members. Table 6.1 shows that the number of credit societies receiving financing from the Ejidal Bank has remained fairly constant since 1970.

The National Agricultural Credit Bank began providing credit to groups of farmers in 1970. It made credit available to credit societies with 10 or more members, and to solidarity groups with a minimum of three members and a maximum of nine. The solidarity group evolved as the most

TABLE 6.1. The numbers of groups and organized farmers receiving credit from several sources during the period 1969–1973

	Impulsora de Puebla		National Ejidal Credit Bank		National Agricultural Credit Bank		Agricultural Bank of the South		Others*		All sources credit	
Year	No. of groups	No. of farmers	No. of groups	No. of farmers	No. of groups	No. of farmers	No. of groups	No. of farmers	No. of groups	No. of farmers	No. of groups	No. of farmers
1969	0	0	15	413	0	50	55	542	58	1556	128	2561
1970	21	253	59	2122	23	480	52	487	64	1491	219	4833
1971	41	1352	54	2199	58	1114	20	296	10	279	183	5240
1972	50	1514	52	2499	261	1774	13	183	9	232	385	6202
1973	62	1459	60	2410	314	1865	5	40	112	1420	553	7194

* The 58 groups in 1969 and 64 groups in 1970 received credit from Agrónomos Unidos, a fertilizer distributor. The 10 groups in 1971 and 9 groups in 1972 received credit from the owner of the Hacienda Coxtocan. The 112 groups in 1973 received credit from Coxtocan and two fertilizer distributors, Agroquímica Olmeca and Guano-Mex.

attractive type of organization to the farmers, as it is very easy to form and only one member of the group has to file the title to his land with the bank as a guarantee. (The members of a solidarity group accept common responsibility for debts incurred by the group.) As shown in Table 6.1, the number of farmers receiving credit from the Agricultural Bank increased to 1,865 in 1973, and the number of groups to 314.

Since 1970, the technical assistance agents have recommended the subdivision of large credit groups or societies. In many villages, groups that receive credit from the Impulsora and have more than 20 members have divided to form groups of about 10 members. Each of these subgroups has a leader or assistant representative. Coordinating the assistant representatives, there is a general representative or coordinator who is elected by all the members and is responsible for the organization at the village level. This subdivision of large groups into smaller units facilitates administration, internal communication, and contact with the technical assistance agents.

The solidarity groups that work with the Agricultural Bank have been encouraged to develop a similar organization at the village level. Many of the solidarity groups have preferred to maintain their independence, however, and this has limited the effectiveness of their village coordinators.

Beginning in 1973, vigilance committees have been formed in the villages with several subgroups receiving credit from the Impulsora or the Agricultural Bank. These committees are composed of one member from each of the subgroups in the village.

BENEFITS RECEIVED BY FARMERS THROUGH ORGANIZED ACTION

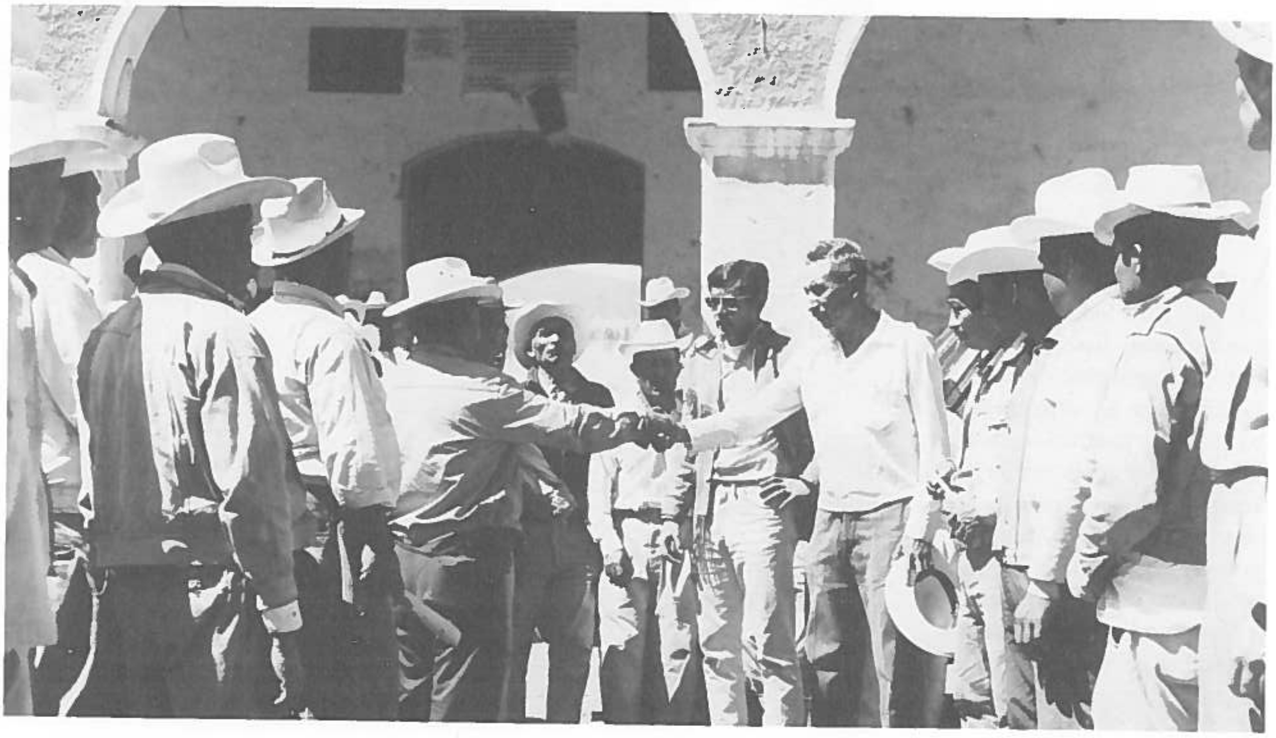
When the technical assistance agents began to promote the organization of farmers in 1969, it was assumed that organized action by farmers would be fruitful in many ways. In 1973, selected farmers were asked whether they were receiving benefits from working together in groups. Information was collected from 69 farmers in 35 groups scattered throughout the Project area. Some of the impressions obtained from the farmers about the importance of organized group action are cited in the following sections.

Better Understanding of the New Technology

The general impression of the farmers seems to be that organization has given them greater access to information about Project recommendations. Most of the meetings and demonstrations at which the technical assistance agents provide information on production practices are organized by the groups. Members of the groups are quite consistent in attending these sessions, and a better understanding of the new technology by the organized farmers should lead to a more effective use of the recommendations.

The difference between the average yields of farmers on credit lists and all farmers in the area (Table 9.8) has gradually decreases over the years. This seems to indicate that an increasing number of farmers not on credit lists are using the new technology. Perhaps, in terms of better information on technology, the advantages of being organized are most notable in the early years of the program.

From 1969 onward, the technical assistance agents concentrated their efforts on promoting the organization of the farmers and in assisting the groups to use the improved production technologies adequately. By 1973, 7,194 farmers were organized in 553 groups and received credit from seven different sources.



Access of Small Farmers to Agricultural Credit

In practice, it is almost impossible for individual small landholders to receive credit from an official bank or a private institution. This is due to the high administrative cost of a small loan, and to the fact that most small holders, on an individual basis, cannot provide the guarantee required by the credit agency.

Farmers organized in groups receive credit from the Impulsora de Puebla without providing any guarantee. For the organized farmers to receive credit from the National Agricultural Credit Bank, it is sufficient that one member of the group deposits the title to his land with the bank. By organizing into groups, it was possible for the number of small farmers receiving credit in Puebla to increase from a few hundred in 1968 to 7,194 in 1973 (Table 6.1).

Greater Efficiency in Obtaining Credit

Farmers are convinced that group action greatly expedites the arranging for institutional credit. The representatives of groups take care of most of the formalities required in securing credit. After the necessary papers have been prepared by the credit agency, the group representatives collect the signatures of the farmers on the individual documents that specify the debt of each client.

The National Agricultural Credit Bank is the only agency that requires all members of the group to go to the bank to sign the individual documents specifying the amount of the loan. Some groups require all members to assist in picking up the fertilizers from the bank, or fertilizer distributor, to reduce costs.

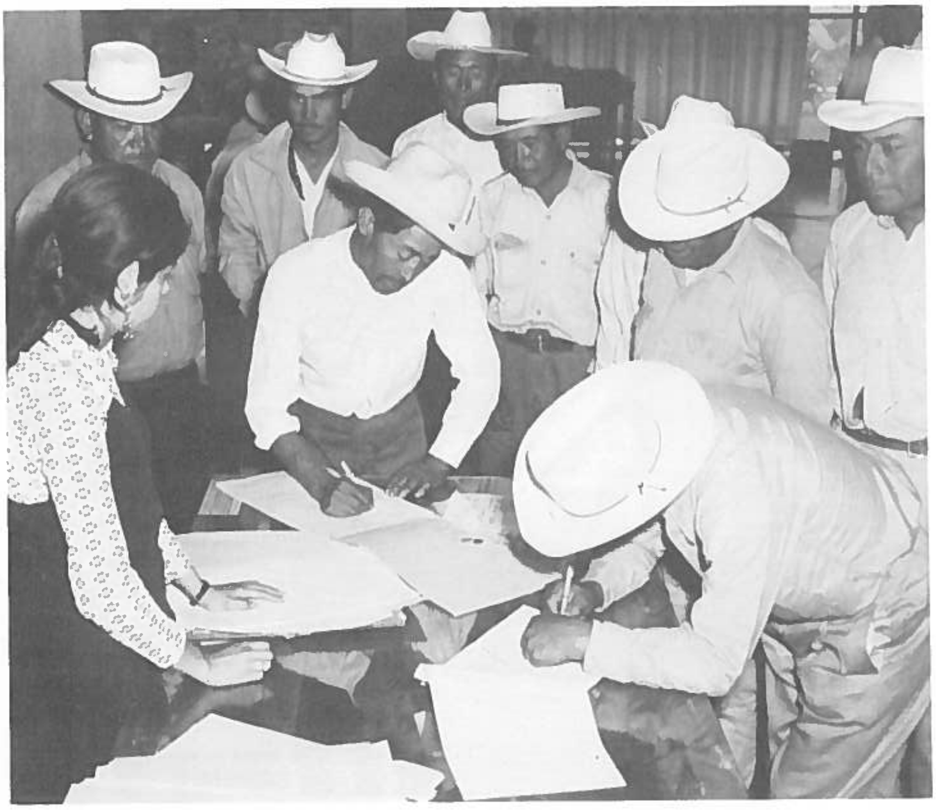
In arranging for credit and picking up the fertilizers, group representatives made an average of 5.6 trips to the credit agency in 1973. The other members of the groups, however, made an average of only 1.7 trips. About 47 percent of the group members did not go to the agency at all; the representatives, assisted by the bank inspectors or the technical assistance agents, took care of all formalities. The costs of the trips of the representatives to the agencies were covered by group funds.

Prompt Delivery of Fertilizers

According to the farmers interviewed in 1973, the credit groups have been effective in reducing delays in the delivery of fertilizers. Apparently the pressure brought by the groups, reinforced by the technical assistance agents, has created a new awareness on the part of the three credit banks and the Impulsora of the importance of timely delivery of the fertilizers. The delays in fertilizer deliveries that have occurred in the last few years have been due to deficiencies in the distribution of materials at the national level, not to faulty scheduling of farmers' needs by the agencies in Puebla.

Efficient and Cheaper Transport of Fertilizers

Another reason organized farmers have been receiving their fertilizers on time is that the groups themselves have made the arrangements for the transportation of the materials. After the group representative receives the delivery order, he and the other members of the group hire a truck to haul the fertilizers at as low a cost as possible. If available, a trucker from the local village is hired for the job.



In the past individual small landholders have found it almost impossible to obtain credit from an official bank or private institution. Small farmers in Puebla, by organizing, have been able to arrange for credit. Moreover, group representatives are able to handle many of the requirements for obtaining loans, thus simplifying for organized farmers the process of arranging for credit.

Ordinarily, a group is able to arrange for the hauling of fertilizers for $2.40/ton. If the members of the group load the fertilizers at the warehouse and unload them at their houses, the cost is about $1.60/ton. Earlier, when farmers had to arrange for transportation individually, the cost was often as much as $4.80/ton., not including loading and unloading.

Prompt Repayment of Loans

Prior to the Puebla Project, only about 50 percent of the short-term loans made by the official credit banks were repaid. In 1971 and 1972, the repayment rate to the Ejidal and Agricultural Banks was over 90 percent; the rate was about 98 percent to the Impulsora de Puebla.

Very probably, one of the reasons for the high level of repayment is the profitability of the new maize recommendations. An even more important reason, perhaps, is the fact that the majority of the organized farmers have accepted a common responsibility for the debts of all members of the group. Each farmer knows that all members of the group must repay loans on time in order for the group to qualify for credit the following season.

When one or more members of a group fail to repay their loans, the rest of the group takes action to assure repayment. As a first step, in most cases, the group representative calls on the defaulting farmer to ask him to pay within a fixed period. If failure to pay was due to unusual family problems, or a poor harvest due to uncontrollable factors, then the other members of the group may cooperate to repay the debt and collect later when the farmer is better able to make payment.

In some groups, if a member fails to pay because of irresponsibility, the group takes firmer action to liquidate this debt. In a few instances, the group demands some item of property (mule, ox, plow, sewing machine, etc.) and does not return it until the offender pays his debt. If the defaulting member continues to refuse to pay, he is expelled from the group, and the other members repay the loan in order to obtain credit for the following season.

One group, after trying to convince three irresponsible members to repay their loans in 1972, took the extreme measure of putting them in jail. Contrary to what might be expected as a result of this action (distrust and doubt on the part of new members), membership in this group climbed from 111 in 1972 to 200 in 1973. After a few days in jail, the defaulting members repaid their loans and petitioned the group to be readmitted, promising to be more responsible in the future. The group's decision, however, was for permanent expulsion of the three farmers.

Another reason for the high repayment of loans in recent years is the fact that the credit agencies, with the exception of the Ejidal Bank, have initiated the practice of discounting interest for those who repay their loans before they become due. Farmers with additional income during the year prefer to pay off their loans in installments, thus saving money they would have paid out in interest. Approximately 45 percent of the farmers interviewed in 1973 liquidated their loans by making several payments throughout the year.

Greater Efficiency in the Repayment of Loans

Many of the farmers receiving credit from the Agricultural Bank or the Impulsora de Puebla make payments on their loans directly to the general representative or coordinator. This coordinator travels once a week to the agency concerned, delivers the payments, and obtains the necessary receipts. Thus, members not only save money on travel and meals, but also time and effort. Generally, the expenses of the representative are paid from a fund raised by the group specifically for this type of activity.

Access to Information on Other Activities

According to the 35 representatives interviewed in 1973, 28 of the groups held an average of four meetings during the year; the other seven held no meetings. The technical assistance agents participated in about 37 percent of these gatherings. The principal themes discussed at these meetings were agricultural credit and the correct use of the new maize technology. Other subjects of interest to the farmers, such as the pruning and grafting of fruit trees, were also discussed in some group meetings.

At harvest time in 1972, demonstrations were held in many communities to show farmers how to construct small trench silos for converting the maize plants into a palatable silage after harvest of the ear but while still partly green. The silo provides an economical means of increasing the supply of good quality animal feed during the dry season.

Demonstrations of the pruning and grafting of fruit trees were made in several communities. In 1971, a technical assistance agent arranged for a group of farmers to attend a short course on pruning and grafting. Farmers who took this course have been useful in assisting other farmers in the Project area to use improved practices in the management of their fruit trees.

Meetings and demonstrations organized by farmer groups have often stimulated interest in a new group activity, such as perforating a well, buying dairy cattle, or acquiring a tractor. There seems to be an increasing awareness among the farmers that the organizations should expand their activities to include a broader spectrum of the problems affecting the community.

Initiation of New Production Activities

At least 10 of the 385 groups functioning in 1972 were involved during the previous 3 years in negotiating a long-term loan for some new group activity. Most of these loans had been requested for deep well perforations to convert a part of the rainfed land into irrigated fields. These wells make possible the production of higher-income crops, such as alfalfa and vegetables, and they can be grown throughout the year. Interest in this organized activity began to develop after the groups were successful in using short-term credit for maize production.

The technical assistance agents played a leading role in this group work, from the formulation of the idea of a loan to the reality of irrigated fields. They provided information on the possibilities of long-term financing, helped the representatives make contact with the credit institution that could grant the loan, and encouraged the members of the groups to have confidence in their capacity to work together and in the honesty of their representatives. As the transactions for the loans progressed, the role of the technical assistance agents tended to decline in importance, while that of the representatives increased.

One of the groups that perforated a well and began to produce higher income crops used the profits for a down payment on a tractor costing $7,200. The tractor is being used for preparing the lands of the farmers of the group, and also for custom work for other farmers in the community, to complete payments on the tractor more quickly.

In a section of the Project area where fruit production is important, several groups have begun to use improved technology in the management of their orchards. With the assistance of a specialist in fruit culture, the farmers have obtained improved varieties and transplanted them to carefully prepared land. There is usually one man in the group, or in the community, who has learned the proper techniques for pruning and grafting and can teach the other farmers.

Greater Effectiveness in Solving Community Problems

Some credit groups that have functioned for several years and have developed relatively strong organizations have been able to solve some of the other problems affecting the community. The traditional holders of power in the communities have come to view these groups as a threat to their position. Local fertilizer dealers fear that the organized farmers will buy outside the community, or demand that the dealers respect prices fixed by the national fertilizer agency.

In one community, a local merchant almost went bankrupt in 1971 when most of the farmers, organized in groups, began to purchase the recommended fertilizers through one of the credit agencies. The following year, the merchant switched from conventional fertilizers to those recommended by the technical assistance agent in hope of regaining his clients. Since most of the farmers were organized, however, few of them purchased fertilizers from the merchant. (According to several representatives, the merchant was prone to take advantage of temporary shortages of fertilizers by increasing his prices, sometimes doubling the official price.) In retaliation, the merchant began to try to discredit the credit groups. Among other actions, he circulated the rumor that some groups were admitting irresponsible farmers who were unlikely to repay their loans. When this rumor reached the credit institutions in early 1973, some institutions decided not to accept new clients in groups from that community.

When the farmers learned of the action of the credit institutions, however, they solicited the help of the technical assistance agent to find a way to convince the institutions to accept new clients. The group representatives and technical assistance agent presented their complaint to the directors of the credit institutions, but could not obtain an alteration in policy. It appeared that the merchant's scheme had been successful.

Nonetheless, the farmers named a commission to present their complaint to the Governor and explain why the credit institutions had refused to accept new clients from their community. The commission described the standards for admitting new members into the groups to the Governor, showing that only responsible people were accepted. The Governor immediately summoned the directors of the institutions and asked them to attend to the farmers' petition.

Greater Interchange of Experiences Among Farmers

As reported in Chapter 5, visits by groups of farmers to other communities in the area were beneficial in many ways. The visitors were able to directly observe the farming activities of the group sponsoring the interchange. An informal dialogue between visitors and hosts, with the technical assistance agent as mediator, helped members of all groups exchange ideas and experiences about many farming and nonfarming activities. Farmers often returned home with new impressions about the possibilities for long-term credit for perforating a well, or the establishment of a small-scale dairy enterprise, fattening of pigs, pruning and grafting of fruit trees, etc.

In 1971, a technical assistance agent in one of the principal towns in the area organized another form of exchange of ideas among farmers. Farmers who came to town for the weekly market day were invited to attend an afternoon meeting, after marketing activities had been completed. On these occasions, about 50 farmers (mainly group representatives) assembled for a lecture on a subject of current interest to the farmers. The presentation was made by the technical assistance agent or a specialist invited specifically for the occasion. When the specialists spoke, the technical assistance agent introduced the speaker and tried to clarify any parts of the talk which he felt the farmers might not understand. Following the presentation, there was a discussion period with active participation by the farmers. This discussion period was essential in providing the participants with new ideas and information to communicate to their groups on returning to their communities.

FACTORS FAVORING GROUP EFFICIENCY

Quality of Leadership

Groups that chose a good leader at the outset have consistently maintained good cooperation from their members and have been able to fulfill all their obligations. Groups with good representatives held the largest number of meetings in 1972. Ordinarily, the representatives of these groups sought out the technical assistance agent, or the Project coordinator, and requested a talk on a specific subject. Then the assistant representatives were notified of the meeting and they, in turn, advised the members. Thus, most members attended and maximum value was obtained from the talk and subsequent discussion.

In contrast, the representatives who were considered unreliable rarely held a meeting of interest to the group. They seldom took the initiative in presenting group problems to the technical assistance agent, or in inviting him to give a talk in the community.

Three of the 35 representatives interviewed in 1973 had not repaid their loans on time. The members of these three groups recognized that they had made a mistake in electing the representatives. They pointed out, however, that it is very difficult to select the right person. According to the members of the groups with the irresponsible representatives, these three individuals had previously had a good record in the community; and, while the groups were being formed, they had been very active and had given the impression they would diligently serve the interests of the group.

Legalization of the Organization

Two of the 35 groups studied in 1973 had drawn up documents outlining the regulations governing the functioning of the groups, and the penalties that would be imposed on violators. These documents had been signed by the members of the groups, the assistant representatives, the general representative, and the municipal president, and had been registered at the municipal headquarters. In this way, the groups acquired legal power to take action against a member in case he should deliberately cause problems.

Legalization of the organizations at the municipal level is viewed by most groups as a useful step in making the groups more efficient. In the future, it is expected that the technical assistance agents can guide other groups in drafting by-laws and in registering them with the municipal authorities.

OUTLOOK FOR MORE ADVANCED FORMS OF ORGANIZATION

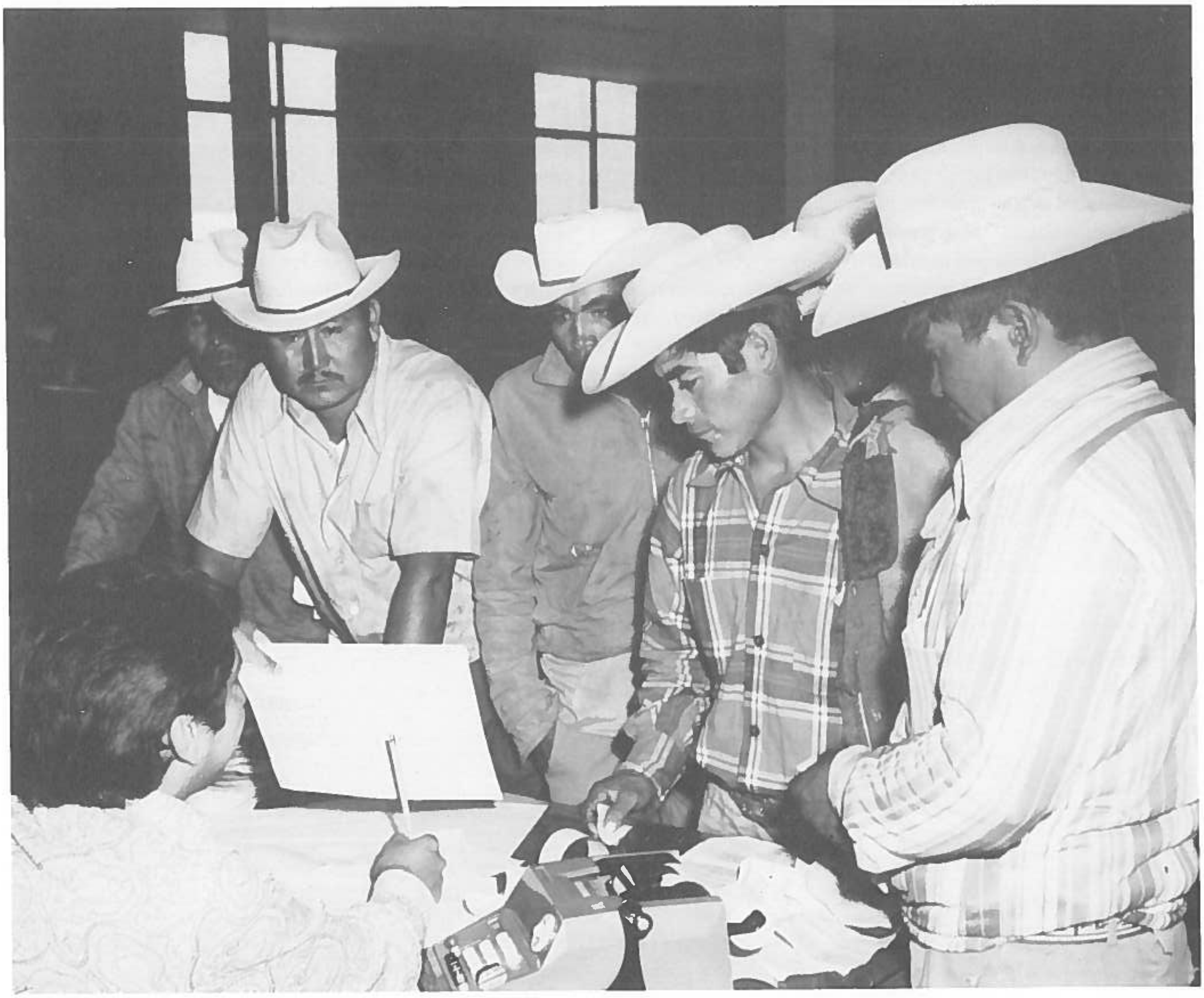
The information collected in the study of the farmer organizations indicates that several of the groups have made outstanding progress in learning how to work together in resolving problems of common interest. These groups are now ready to move to higher forms of organization, such as cooperatives.

The evolution from credit groups to more complex organizational forms will require the assistance of people well trained in the theory and practice of farmer organization. It seems logical that the technical assistance agent could best provide this assistance in a program such as the Puebla Project. The present agents in Puebla, however, are not technically prepared to do this job. To remedy this situation, the technical assistance agents could receive specialized training related to the operation of farmer organizations.

SUMMARY

The experiences gained in Puebla since 1969 support the thesis that a very simple organizational form, such as the credit group, should be used in the initial stages of organizing farmers who may often be distrustful and individualistic, with limited managerial ability. After the farmers have gained confidence in the Project, and experience in collective action, and have developed responsible leaders with administrative capacity, then higher forms of organization may be achieved. It is expected that this second stage will be much more complex than the first, and will require technical assistance agents well trained in the organization of farmers.

Three official credit banks – National Agricultural Credit Bank, National Ejidal Credit Bank, Agricultural Bank of the South – have made loans to enable organized farmers to use project recommendations. The total area financed by the first two of the these banks increased from 1,516 ha. in 1969, to 13,617 ha. in 1973.



7 THE AGRICULTURAL SERVICE AGENCIES

INTRODUCTION

A part of the general strategy of the Puebla Project has been to assure that the farmers have access to materials and services essential for favorable change. Some of these services were being provided by public and private institutions in Puebla at the time the Project began, including: (a) production credit, (b) agronomic inputs at a favorable price, (c) crop insurance, and (d) an accessible market for farm produce, with a guaranteed price.

Since these services were available in Puebla in 1967, the Project concentrated initially on agronomic research. Had some of these services not been available, it is unlikely that the Project would have tried to provide them. Rather the Project would have sought a solution through encouragement of government action to create the institutions needed.

The role of the Puebla Project in working with the institutions (those involved in credit, the distribution of inputs, crop insurance, and marketing) has been that of assuring that these services are adequate for small farmers. The Project Coordinator assumed the major responsibility for this activity.

Planners of the Project felt it important that the Project be promoted as a joint effort of all the agricultural agencies, with representatives of the different institutions to be fully informed of Project activities and the needs of the farmers. As greater experience was gained, however, it became evident that some of the operating procedures of some institutions were restricting farmer use of their services. It was clearly necessary that Project staff should more fully understand the operations of these institutions and the way they reached decisions on farmers' requests. Thus, the staff began a more systematic effort to assess these institutional procedures.

After a problem had been fully analyzed, the Project staff proceeded to explain the nature of the problem to the indicated agency, usually working through the coordinator. Full cooperation was given to the agency in finding ways to improve its services to the farmers. This proved to be a most difficult task, however, and progress in improving the operating procedures of the service institutions has been modest.

In this chapter, certain characteristics of the service institutions in Puebla, their operating procedures, and their accomplishments are described briefly. Changes in the institutions that have contributed to improved services are reported, as well as problems remaining to be resolved.

THE IMPULSORA DE PUEBLA

The production and distribution of chemical fertilizers in Mexico is the responsibility of a decentralized agency of the federal government, Guanos y Fertilizantes de México (Guanomex). When the Puebla Project began in 1967, Guanomex had three authorized dealers in the state, Impulsora de Puebla and two others, all private companies. In addition, there was a network of local distributors in the villages, mainly retail dealers who purchased fertilizers in the city of Puebla or Mexico City and resold them to the farmers.

Guanomex changed some of its operating procedures in early 1971 when the three authorized distributors in Puebla were made official commission agents of Guanomex, each with the concession to distribute certain specific materials at a fixed commission. Impulsora de Puebla became the principal agent with the concession to handle low-concentration materials and mixtures. According to the new policy, local distributors in the villages would no longer be permitted to purchase fertilizers from the official agents; thus, they became less important in the distribution network.

Impulsora de Puebla, since its establishment many years ago, has functioned both as a fertilizer distributor and as a credit agency. Prior to 1968, the Impulsora had provided credit only to commercial or semi-commercial farmers who could offer security. In 1968, a sub-distributor of the Impulsora, Agrónomos Unidos, agreed to provide fertilizers on credit to the first farmers who decided to use Project recommendations on a part of their maize planting. These were all small farmers and were not required to put up collateral. Impulsora backed Agrónomos Unidos in this credit operation.

In 1969, Impulsora continued to back Agrónomos Unidos in its financing of small farmers who used the Puebla Project maize recommendations. In 1970, Impulsora continued its participation through Agrónomos Unidos and, in addition, provided credit directly to 253 farmers in 21 groups. Impulsora absorbed the clients of Agrónomos Unidos at the end of 1970, and has continued this credit program for small farmers.

Table 7.1 shows the number of hectares financed, total amount of credit, and percentage repayment of loans within the credit operation of Impulsora, both for credit obtained directly and that obtained through Agrónomos Unidos in the years 1968-1973. Impulsora's credit program peaked in 1970 and has remained quite static since then. This has been true in spite of a growing demand from the farmers for more credit from Impulsora and an average repayment rate of about 98 percent.

Procedure Followed in Granting Credit

The procedure followed by the Impulsora in granting credit to small farmers is very attractive, since it does not require any security from the farmers. All that the Impulsora requires is a guarantee of the total operation by a responsible agency. CIMMYT provided this guarantee in 1968 when only $6,000 was loaned. Beginning in 1969, the credit operation of the Impulsora was endorsed by the Agricultural Agent, who is the state representative of the Ministry of Agriculture.

In 1969 and 1970, the endorsement of the Agriculture Agent was not backed up by adequate funds to fully guarantee the credit operation. In 1971, however, a special fund was formed by collecting a tax of $0.40/ton on all fertilizers sold on credit or for cash by the three official agents of Guanomex and the official credit banks. This fund is administered by the State Fertilization Committee, whose chairman is the Agricultural Agent. Since the establishment of this fund, the guarantee of the credit program of the Impulsora has been effective. When the Fertilization Committee reimburses the Impulsora for loans not repaid on time, it receives the promissory notes of the indebted farmers, with the expectation of repayment at a later date.

The Impulsora procedure for granting credit is as follows: (a) representatives of the sub-groups prepare lists of the members desiring credit, and of the number of hectares for which financing is requested; (b) the group coordinator consolidates the lists of the different sub-groups and delivers the request to the Impulsora; (c) the technical assistance agents of the Puebla Project give the Impulsora a list of all the communities in their zones with groups requesting credit, along with the recommended fertilizer rates; (d) the secretaries of the Impulsora or the Puebla Project draw up documents for each farmer, specifying the amount of fertilizers and credit requested; (e) these documents are given to the group coordinators, who, with the representatives, obtain the signatures of the farmers; (f) the documents are then signed by the group coordinators and returned to the Impulsora; and (g) the delivery order is given, specifying the date the farmers must pick up the fertilizers at the company warehouse. In 1972, the average time required was 36 days from the preparation of lists to the issuing of the delivery order, with extremes of 3 days and 6 weeks.

Changes in Sales of 10-8-4

According to survey data, 64 percent of the farmers who applied chemical fertilizers in 1967 used the 10-8-4 mixture, containing 10 percent nitrogen (N), 8 percent phosphorus (P_2O_5), and 4 percent potassium (K_2O). Agronomic research on farmers' fields, however, has not revealed important deficiencies of potassium; thus, the Project has recommended that farmers apply only nitrogen and phosphorus. Moreover, the Project has suggested that farmers purchase nitrogenous and phosphatic materials separately and prepare their own mixtures, to obtain the right proportions of the two elements.

The relative importance of 10-8-4 in total sales of the Impulsora declined markedly in 1969. The 10-8-4 mixture represented approximately 76 percent of the total nitrogen sold by the Impulsora in the period 1966-1968, whereas only 27 percent of the nitrogen sold in the years 1969-1972 was in the form of 10-8-4. In general, there has been a shift from 10-8-4 to ammonium sulfate, superhosphate, and non-potassic mixtures, (such as 12-8-0, 10-10-0, and 5-14-0).

TABLE 7.1. The credit provided by several agencies to enable farmers to use Project recommendations for maize during the years 1968-1973.

	Impulsora de Puebla			National Agricultural Credit Bank			National Ejidal Credit Bank			Agricultural Bank of the South			Total	
Year	No. of hectares	Amount of credit	% repay-ment	No. of hectares	Amount of credit	% repay. ment	No. of hectares	Amount of credit	% repay-ment	No. of hectares	Amount of credit	% repay-ment	No. of hectares*	Amount of credit
1968	76	6,000	100.0										76	6,000
1969	2,719	165,059	96.0	687	48,802	50.0	829	50,846	55.5	1,603	105,132	50.0	5,838	369,839
1970	4,682	191,163	97.5	1,788	148,250	51.2	4,522	282,256	72.0	1,609	123,175	60.0	12,601	744,844
1971	3,228	108,807	99.5	4,950	202,972	91.6	4,920	294,347	91.0	1,172	90,080	62.0	14,438	696,206
1972	4,108	153,953	98.5	7,499	383,282	93.9	5,105	398,722	90.0	822	39,854	50.0	17,533	975,811
1973	4,220			8,207	419,452		5,410	422,584		293	14,202		20,604	

* The total number of hectares for 1971 includes 168 with credit guaranteed by the Coxtocan Hacienda; the total for 1973 includes 2,474 ha that were financed by Guanomex and the Olmeca fertilizer company.

The Puebla Project seems to have been largely responsible for this change from 10-8-4 to more adequate fertilizers. Sales of ammonium sulfate and superphosphate have increased as a direct result of the growing demand for these materials by farmers using Project recommendations. According to the manager of the Impulsora, his company has given greater importance to the 10-10-0 and 12-8-0 mixtures since 1971, because the field trials conducted in the area showed little response to potassium.

Outlook for Greater Credit for Small Farmers From the Impulsora de Puebla

As mentioned earlier, the credit provided to small farmers by the Impulsora has not increased since 1970, in spite of a repayment rate of around 98 percent. This is due mainly to the low interest rate which the Impulsora is required to charge on fertilizer credit. According to the modified Guanomex policy that became effective in 1971, 9 percent per year is the maximum interest that the Impulsora can charge farmers receiving fertilizers on credit. Since the Impulsora acquires the fertilizers from Guanomex at 6 percent interest, its income from interest on credit sales is 3 percent per year. However, as credit is usually extended to farmers for a period of about 9 months, the effective income from interest is less than 3 percent. Under these conditions, the tendency of the Impulsora is to increase its cash sales and keep sales on credit to a minimum.

Perhaps permission to charge a higher interest rate is the only measure that will induce the Impulsora to increase its sales on credit in the future. Farmers should find Impulsora credit attractive, even with a higher interest rate, because of the simplicity of the credit-granting procedure.

THE PUEBLA BRANCH OF THE NATIONAL AGRICULTURAL CREDIT BANK

The National Agricultural Credit Bank was founded in 1926 as an integral part of the agrarian reform program of the post-revolutionary governments. Branches of the bank were established throughout the country to: (a) promote the organization of *ejidatarios* and small landholders, (b) make available production credit at locations accessible to these farmers, and (c) provide for credit at an interest rate more attractive than that charged by local moneylenders. The mandate of the Bank stipulated that possible social benefits be considered as well as the solvency of the client, in deciding how to allocate its funds.

The law regulating the National Agricultural Credit Bank was modified in 1935 with the creation of the National Ejidal Credit Bank. Since then, the Agricultural Bank has provided credit exclusively to landowners, and the Ejidal Bank has worked with the *ejidatarios*. The law governing the Agricultural Bank was again modified in 1956 in an attempt to make its services more dynamic.

The National Agricultural Credit Bank has branch banks in every state. Most branches have sub-branches or agencies that are located at strategic points. The zone corresponding to a given agency is divided into sub-zones, with a field inspector in charge of each of them. The Puebla Branch of the Agricultural Bank has six agencies, two of which provide credit to farmers in the Project area.

The Project coordinator works closely with the representatives of the agricultural service agencies. He provides information on the findings of the Project and obstacles limiting farmer use of the available services, and assists in finding ways to eliminate such obstacles.

The National Agricultural Credit Bank makes three types of loans to small farmers organized into solidarity groups: (a) short-term loans (maximum 12 months), mainly for purchase of inputs for annual crops at 10.5 percent/year interest; (b) intermediate-term loans (1 to 5 years) to acquire work animals, farm machinery, dairy cattle, etc., at 9 to 10 percent/year interest; and (c) long-term loans (6 to 10 years) to purchase heavy machinery or construct farm buildings at 7 to 10 percent/year interest.

The majority of the farmers in the Project area are not eligible for individual credit from the Agricultural Bank, because their holdings are too small. Although the regulations of the Agricultural Bank provide for the organization of credit societies, none of these were operating when the Project began in 1967. As seen in Table 7.1 the Agricultural Bank provided credit for farmers to use Project recommendations on 687 ha in 1969 and on 1,788 ha in 1970. In 1969, credit was granted to individual farmers; in 1970, to 23 groups with a total of 480 farmers. These groups, however, were poorly organized and there was little contact with the technical assistance agents. Repayment was made on only about 50 percent of the loans made in these two years.

In 1971, the Agricultural Bank and the Project technical assistance agents began to promote the organization of solidarity groups. These groups have a maximum membership of nine and a minimum of three. According to bank regulations each member of these groups must mortgage his land to the bank in order to obtain credit. As most small farmers do not have a clear title to their land, the Puebla Branch of the Agricultural Bank obtained authorization to change this requirement. Now, the only requirement is that one member of the group has a clear title to his land and is willing to mortgage it to the bank. This change in regulations has made it possible for many farmers who were previously unable to qualify for loans to obtain credit as members of a solidarity group.

Organized farmers are encouraged to repay their loans as soon as possible. Many farmers liquidate their loans by making several payments throughout the year. In 1972, the percentage repayment on loans from the Impulsora de Puebla was 98%, from the National Agricultural Credit Bank 94%, and from the National Ejidal Credit Bank 90%.

With the change to solidarity groups in 1971, the Agricultural Bank has greatly increased its credit to farmers using Project recommendations. Table 7.1, shows that the Agricultural Bank provided credit for 4,950 ha in 1971; 7,499 ha in 1972; and 8,207 ha in 1973. Repayment of loans by solidarity groups exceeded 90 percent during this period.

Operating Procedures of the Agricultural Bank

Farmers in solidarity groups follow these steps in arranging for credit with the Agricultural Bank: (a) the group representative prepares a list of the members that indicates their ages, beneficiaries in the case of death, and the areas for which credit is requested; (b) one farmer with a clear title to his property agrees to guarantee the group loan—both he and his wife must register their signatures with the legal department of the bank; (c) each member presents the receipt for his most recent property tax payment, or a letter from the highest authority in the community certifying that he is a property owner; (d) the representative obtains a written statement from the technical assistance agent indicating the fertilizer rates recommended for the group; (e) a credit application is drawn up for the group, specifying the total area for which credit is requested and the total amount of credit—this application is signed by the group representative, by the guarantor, and by the technical assistance agent; (f) based on the application, a special form, called F-200, is prepared as a credit application from the group to the Planning Council of the bank—these F-200's have to be signed by five persons in the Credit, Legal, and Administrative Departments, as well as by the bank manager; (g) the group signs a contract with the bank for the amount of credit requested—the contract must be registered in the city of Puebla with the payment of a registration fee of $8.00; the contract is good for 5 years, provided there are no changes in the group; (h) all members sign a formal charter, specifying that they assume a common responsibility for the obligations of the group--this means that should any member fail to repay his loan, the others are obligated to find a way to liquidate it; (i) each member signs a letter in which he agrees to repay his loan with the produce from the land for which credit was received; (j) multiple promissory notes are drafted showing the cost of fertilizers, amount of interest, and other charges for each member—these documents are prepared with 18 copies and signed by all members of the group; and, finally (k) the guarantor deposits a letter with the bank giving it power to take possession of his property in case the group fails to meet its obligations.

In 1972, this procedure required an average of 13 days from the time the application was presented until the group received the order to pick up the fertilizers. Some groups were able to complete this process in 3 days; others required as much as 4 weeks.

Some farmers felt this procedure for arranging for credit was too complicated and chose not to join a solidarity group. Other farmers were discouraged from seeking credit through the Agricultural Bank because of the requirement that they take crop insurance. (This latter problem is common for the three official banks and is discussed in a later section.)

When the number of farmers seeking credit from the Agricultural Bank increased sharply in 1971, the bank ran short of personnel to handle the loan requests. The farmers in solidarity groups suggested that the Bank use the 1 percent of their loans that is deducted by law for administrative costs to pay temporary personnel. The director of the Bank presented the proposal to the local administrative council and obtained the necessary approval.

Outlook for Greater Credit for Small Farmers From the Agricultural Bank

The Agricultural Bank has become a strong supporter of the Project strategy and has fostered close coordination of Bank and Project personnel in their relationships with the farmers. Both the Puebla Branch and the Central Office of the Agricultural Bank are pleased with their credit program for solidarity groups using Project recommendations. All indications are that the Agricultural Bank will seek to increase this credit operation. Prospects for this increase were strengthened in 1973 when the Agricultural Bank received authorization to extend credit to *ejidatarios* as well as landowners.

Nevertheless, if the Agricultural Bank is to respond fully to the growing demand for production credit in the Puebla area, it will be necessary to resolve several problems that presently limit the effectiveness of the bank's credit program: (a) the work load of employees of the Legal and Administrative Departments has increased greatly since 1971–it seems reasonable their salaries should be adjusted to compensate for this work, and to put their salaries in line with those received by employees of the other official banks; (b) bank regulations require that a new contract be signed with a solidarity group when members leave, when new members enter, or when there is a change in the area for which credit is requested. Since such changes are frequent, it is necessary to sign a new contract almost every year. Farmers feel that the bank should be more flexible and permit changes in membership and acreage without the trouble and expense of drawing up and registering a new contract; (c) the Agricultural Bank is the only official bank that deducts interest in advance. A farmer who requests $100 at 11.5 percent interest, for example, receives $88.50 and has to pay back $100 at the end of the year. The effective interest rate is 12.99 percent instead of 11.5 percent. The farmers feel that this method of calculating interest should be changed; and (d) the temporary personnel hired for the peak work periods are usually poorly paid and inefficient. Thus, many documents have to be redone, causing delays and a great deal of frustration for the farmers.

THE PUEBLA BRANCH OF THE NATIONAL EJIDAL CREDIT BANK

The National Ejidal Credit Bank was founded in 1935 and since that time has granted credit to *ejidatarios*, with the Agricultural Bank providing credit to landowners. In addition to extending credit to *ejidatarios*, the Ejidal Bank objectives were: to organize the *ejidatarios* to work their lands collectively, and to make credit more accessible by establishing state and regional branches. The Puebla Branch of the Ejidal Bank has seven agencies at strategic locations in the state. Each agency has several field inspectors, each of whom is responsible for attending the *ejidatarios* in a given zone. Two agencies are located in the Project area and have provided credit to *ejidatarios* using Project recommendations.

The Ejidal Bank, as in the case of the Agricultural Bank, offers short, intermediate, and long-term loans. The Ejidal Bank makes loans to credit societies and, rarely, to solidarity groups. Credit is not provided to individual *ejidatarios.*

In 1969, the Ejidal Bank granted loans enabling 413 *ejidatarios* in 15 credit societies to use Project recommendations on 829 ha of maize. Although only 55 percent of these loans were repaid (Table 7.1), the Ejidal Bank recognized the potential of the new technology and decided to reinstate 44 *ejidal* societies that had lost their credit standing in the past due to failure of their members to repay loans. In 1970, the Bank provided credit for 2,122 *ejidatarios* in 59 credit societies with a total of 4,522 ha. Table 7.1 shows that the number of hectares of maize plantings financed by the Ejidal Bank has remained fairly constant since 1970. About 90 percent of these loans have been repaid.

Operating Procedures of the Ejidal Bank

To qualify for loans from the Ejidal Bank, the *ejidatarios* must organize a credit society. The requirements for chartering a society are: (a) at least 10 *ejidatarios* must request the founding of a society; (b) the ejidal executive committee must submit an application for the formation of a society, along with a map of the *ejido* showing the location of the parcels of the applicants; (c) each applicant must present his ejidal certificate, or proof that his name appears on the most recent ejidal census list–this is necessary to establish that each of the applicants has possession of an ejidal parcel; (d) the field inspector of the Ejidal Bank prepares a document specifying the socioeconomic conditions of the applicants and the productive potential of their soils; (e) the Puebla Branch of the Ejidal Bank sends the application of the *ejidatarios*, the map of the *ejido*, and the document prepared by the field inspector to the Central Office; and (f) the Central Office approves or disapproves the application.

There is at least a 6-month lapse from the time the application for the formation of a credit society is submitted until the Central Office makes a decision. The Bank does provide, however, for the provisional establishment of a society under unusual circumstances and at the request of the manager of the Branch Bank.

After the formation of a credit society has been authorized, the field inspector holds a meeting, in the *ejido*, of all the *ejidatarios* who wish to become members and receive credit from the Ejidal Bank. At this meeting, the *ejidatarios* elect one member of their group, the delegate, to represent the society in all transactions involved in arranging for credit. Once established, the credit society can function indefinitely. New members can be accepted on approval of the membership of the society. The Ejidal Bank is fairly flexible in its relationships with the society and permits it to continue operating even though there are changes in its membership.

The procedure followed by the credit society in arranging for loans from the Ejidal Bank involves several steps: (a) during September preceding the cropping season, the field inspector, with the assistance of the delegate, prepares a list of the credit requirements of each member; (b) the Puebla Branch consolidates the requests from the several societies, prepares a Plan of Operations, and sends it to the Central Office; (c) the Central Office approves all or part of the request and returns it to the Branch Bank; at least one month before planting time, the Branch Bank notifies the agencies of the amount of credit approved for their areas; (d) the field inspector prepares a final list for each society, showing the credit requested by each member (last-minute changes in members requesting credit is permissible); (e) the field inspector, assisted by administrative personnel of the Bank, prepares a contract that specifies the amount of credit requested by the society, both for fertilizers and in cash. A new contract is necessary each year for each type of credit. The *ejidatarios*, however, do not participate in the preparation and registration of the contracts. This is done by the Bank, which pays the registration fee from a special fund collected from society members for administrative expenses; (f) the field inspector draws up a multiple promissory note showing the amount of each member's loan, the interest, and other deductions; (g) the Bank then sends a delivery order to the delegate—with this order, the society members obtain their fertilizers and cash from the Bank; and (h) each member, on receipt of materials or cash, signs the promissory note. In 1972, the average time between the preparation of the final list (step d) and receipt of the delivery order was 28 days.

In an attempt to make the credit-granting process more dynamic, the National Ejidal Credit Bank introduced a series of administrative reforms in 1973. The central feature of these reforms is the creation of Control Boards with an assistant bookkeeper and secretaries, to relieve field inspectors of most of their paper work. Its is hoped that this will enable the field inspectors to devote more time to field activities.

In early 1973, by presidential decree it was stipulated that debts contracted by ejidal credit societies between 1940 and 1965 would be pardoned at the rate of 20 percent for each year that the *ejidatarios* repay new loans on time. Thus, in 5 years, all *ejidatarios* with debts from that period could liquidate the old loans simply by repaying all new loans promptly. The presidential decree further specified that debts contracted between 1966 and 1972 would be combined into one account and repaid gradually without interest. The Bank suggested that each indebted *ejidatario* apply 10 percent of his harvest each year toward paying off his account until it was settled. This new policy for reinstating members of the credit societies should increase the amount of credit granted in 1974 to enable *ejidatarios* to use Project recommendations.

Outlook for Greater Credit for Ejidatarios From the Ejidal Bank

Taking into account the 90-percent rate of loan repayment since 1971 by *ejidatarios* using Project recommendations, it seems likely that the Ejidal Bank will be interested in expanding its credit operation in the Puebla area. To accomplish this, however, the Bank must examine a series of problems that are believed to limit the effectiveness of its credit program, including: (a) eight field inspectors attended 52 societies with 2,499 *ejidatarios* in 1972, an average of 6.5 societies and 312.4 *ejidatarios* per field inspector. This is felt to be about the maximum number of societies and members that can be attended efficiently by one inspector with present operating procedures. It seems clear, therefore, that more inspectors will be needed or operating procedures must be simplified if the Ejidal Bank is to expand its credit operation successfully; (b) In 1969 and 1970, technical assistance agents of the Project focused their efforts on groups receiving credit from the Impulsora de Puebla. Since then, they have tried to work more closely with the ejidal credit societies. In 1973, for the first time, technical assistance agents and bank inspectors began to hold meetings to coordinate their activities. Both groups would benefit from strengthening this relationship in the future to improve their services to the *ejidatarios;* (c) when communicating with Bank administrators, the field inspectors sometimes fail to transmit the nature of problems influencing the behavior of the ejidatarios. This lack of communication results in misunderstandings and strained relationships among Bank employees. Recently, for example, field inspectors were blamed for the failure of many *ejidal* parcels to qualify for crop insurance. However, there was little the inspectors could do, because the problem arose primarily as a result of unrealistic operating polices of the crop insurance agency, plus the tendency of some farmers to encourage rejection (believing the cost of the insurance to be a useless expense). Regular meetings of field inspectors and other bank personnel would permit a freer flow of information and contribute to a smoother functioning of the institution; (d) in past years there have been an excessive number of changes in administrative personnel and field inspectors. In one year, for example, the Bank manager was changed four times. Frequent changes in Bank personnel cause many deficiencies in the bank's services to the *ejidatarios;* and (e) members of the ejidal credit societies are poorly informed of their rights and obligations and few participate in transactions with the Bank. Most members, for example, do not know what percentage of interest they are paying, how much is deducted from their loans for crop insurance, or why other deductions are made. Society members are poorly informed mainly because they fail to attend the meetings held by the field inspector. According to the *ejidatarios*, however, nothing of importance is discussed at the meetings. This situation can be improved in the future if the field inspector will devote more time to visiting the *ejidos*, perhaps soliciting the participation of the technical assistance agents.

AGRICULTURAL BANK OF THE SOUTH

The National Crop and Animal Production Bank was established in 1965, with the function of granting credit to both *ejidatarios* and landowners. Its basic purposes are to assist the Agricultural and Ejidal Banks in serving more farmers, and to seek new ways to make these services more dynamic and efficient.

The National Crop and Animal Production Bank has four regional banks that function independently in administrative matters, each providing service in several states. One of these regional banks, the Agricultural Bank of the South, was established in the city of Puebla in 1967 and serves eight southeastern states, with agencies in each.

The operating procedures of the Agricultural Bank of the South are similar to those of the Ejidal Bank, the difference being that farmers can organize solidarity groups (if their membership is less than 10) or credit societies (if membership is 10 or more). The time required to found a society is about the same as in the case of the Ejidal Bank. An important difference between the Agricultural Bank of the South and Ejidal Bank is that the Ejidal Bank field inspectors collect payments on loans directly in the communities and, when necessary, from the *ejidatarios* in their homes. The field inspectors of the Agricultural Bank of the South do not collect loan payments.

When the Puebla Project began to promote the use of the new maize recommendations, the Project technicians and farmers felt that the potential of the Agricultural Bank of the South for supplying production credit exceeded that of the other official banks. It was new, well-equipped, had well-trained personnel, and was interested in new approaches.

Table 7.1 shows that the credit provided by the Agricultural Bank of the South peaked in 1969 and 1970 and steadily declined in the following three years. This tendency of the bank to reduce its credit program apparently stems from two causes: (a) the percent repayment on loans has been low, only 50 to 62 percent–this low repayment rate can be explained in part by the fact that the Bank's clients have received little technical assistance due to the lack of coordination between the Bank's field technicians and Project personnel; and (b) the Bank does not feel that short-term credit, especially for maize production, is an effective way of helping small farmers. The Bank feels that such loans tend to perpetuate the vicious cycle of poverty-subsistence that is at the root of underdevelopment. In extending credit to a considerable number of farmers in 1969 and 1970, this Bank sought to introduce them to the Bank's services with the aim of promoting long-term loans to make the farmer's operations more productive. Few of the farmers, however, reacted as the Bank had expected.

Since 1972, the Agricultural Bank of the South has promoted a different form of organization, which consists primarily of consolidating the contiguous holdings of a group of farmers and operating the land as a single unit. The bank expects to drill wells and convert most of the land to higher-income, irrigated crops. This organizational model is presently being tried with three societies in the State of Puebla.

In view of the present thinking of the Agricultural Bank of the South, it seems unlikely that the Bank will grant significant amounts of credit in future years to enable farmers to use Project recommendations.

THE COXTOCAN HACIENDA

In 1969, the owner of the Coxtocan Hacienda gave chemical fertilizers to many of the *ejidatarios* who farmed the land adjacent to her property. The following year she was deluged with requests for fertilizers and was forced to look for some other way to assist the *ejidatarios*. The coordinator of the Puebla Project suggested that, rather than give the fertilizers, the *ejidatarios* might request the fertilizer on credit from a distributor, and that she could serve as guarantor for the loans. The Project agreed to organize the *ejidatarios* and provide them with technical assistance.

Since 1971, the owner of the Coxtocan Hacienda has guaranteed the loans for about 250 *ejidatarios* in 10 groups. The credit was extended by the Olmeca fertilizer company in 1971 and by the Impulsora de Puebla in 1972 and 1973. It is not expected that the owner of the Coxtocan Hacienda will be equipped to guarantee the loans of larger numbers of *ejidatarios* in future years.

DIRECT PARTICIPATION OF GUANOMEX

As mentioned earlier, Guanomex is a decentralized federal agency with the responsibility for the production and distribution of chemical fertilizers in Mexico. It initiated a pilot effort in 1973 to promote the use of agua ammonia by organized farmers in the Puebla area. Guanomex feels that nitrogen in the form of agua ammonia can be supplied to small farmers at a cost of only about 60 percent of that of solid fertilizers. An important factor contributing to this lower cost of liquid fertilizers is the feasibility of transferring the personnel and special equipment for handling agua ammonia presently assigned to irrigated areas of the country to rainfed areas for a few months each year.

The Guanomex plan was to provide farmers with horse-drawn applicators and deliver the agua ammonia to their communities in 55-kg tanks that fit directly on the applicators. The farmers had to sign a promissory note on receipt of the fertilizer and agree to repay Guanomex at harvest time.

The Project technical assistance agents began to inform the farmers about the Guanomex program in early April 1973. Over 2,000 farmers volunteered to try the agua ammonia on some 5,000 ha. Several problems arose, however, including delays in installing the agua ammonia plant, and numerous difficulties in adapting the horse-drawn applicator to the conditions in Puebla. Thus, the agua ammonia was applied to only about 500 ha by about 250 farmers.

Project technicians feel that agua ammonia can be an important source of nitrogen for farmers in the Puebla area, if the price can be maintained at around 60 percent of that of solid materials. However, the horse-drawn applicator used in 1973 still has many technical flaws and will have to be improved significantly.

THE NATIONAL AGRICULTURAL INSURANCE AGENCY

About 20 years ago, farmers of the Lagunera Region of Northern Mexico who received credit from the official banks formed a mutual crop insurance association. Each member paid a fixed amount per hectare, and in the case of crop damage, the money was distributed among those members suffering losses in accordance with the recommendations of an inspection committee named by the association. This mutual association was quite successful, and similar agencies were soon formed in other parts of the country. The first mutual association in the State of Puebla was established in 1956 and became a part of the National Agricultural Insurance Agency (ANAGSA) in 1961.

The basic purpose of ANAGSA is to complement the agricultural credit service provided by the official banks, by protecting: (a) the farmers against losses due to natural causes, and (b) the official banks against losses due to the inability of the farmers to repay their loans in unfavorable years. ANAGSA expanded its program in 1972 to include life insurance, which costs the farmer $2.00/year and provides his family with $400 indemnization in case of death.

Table 7.2 shows the hectares of maize insured by ANAGSA in the Puebla area, the premiums paid, and the amounts of indemnizations for the years 1966-1971. Although all farmers applying for official production credit must request crop insurance (except for one line of credit of the Agricultural Bank), ANAGSA normally rejects some of the plantings. For example, in 1971, only about two-thirds of the area receiving credit for maize production was approved for crop insurance.

The average area of maize insured by ANAGSA in 1970-1972 was more than double that of 1966-1969 (Table 7.2). The premiums paid by the farmers accounted for less than one-third of the total premiums; the remainder was paid by the federal government. The area on which indemnization was collected has fluctuated greatly, reflecting variations in climatic conditions over the years.

Operating Procedures of ANAGSA

The procedure used by the official credit banks in requesting crop insurance for their clients is as follows: (a) each bank sends a multiple application to the insurance agency with the areas for which credit is requested and names of all farmers soliciting credit, and (b) as soon as the farmers have signed the contract and promissory notes, the Bank sends a complementary report for each farmer to the insurance agency, showing his age, beneficiary, and the number of parcels in his property that are separated by

TABLE 7.2. The insuring of maize plantings in the Puebla area in 1966-1972.

Year	Area financed by official banks ha	Area insured ha	Amount of premiums	Premiums paid by farmers	Area Indeminized ha	Amount of indemnization
1966	2,973	2723	42,832	- -	271	4,421
1967	3,187	2740	45,161	- -	1185	23,069
1968	3,545	2856	45,405	- -	710	10,130
1969	3,118	2672	45,048	12,456	1840	51,079
1970	7,920	6139	103,408	29,598	1186	34,762
1971	11,043	7068	176,538	45,914	1532	59,304
1972	13,426	5947	- -	- -	- -	

more than 1 km. The insurance agency uses the information in these reports to estimate the number of field inspectors needed and the approximate dates of peak field activities.

Three kinds of field inspections are made. The first inspection is normally made a few weeks after emergence of the crop. Its purpose is to verify that the insured crop was planted, and that plant density and general vigor are satisfactory. The group representative and the members needed to locate the parcels must accompany the field inspector. After each parcel is checked, the inspector draws up a legal document specifying the conditions of the crop. The document is read to all those present and signed by each. The inspector does not inform the farmers at this time whether the parcel is accepted or rejected; this decision is made later by a higher agency official.

The second kind of inspection is made when insured farmers report crop damage due to natural causes. The farmer must advise the insurance agency within 72 hours of the time the damage occurs. The agency must inspect the damaged crop within a period of time specified by the law governing ANAGSA. The damaged crop is inspected by the agency field inspector, accompanied by the bank inspector, group representative, and the farmer concerned. The inspector draws up a legal document specifying the nature and extent of damage and has it signed by all present.

The third kind of inspection is made just before harvest. All plantings that have been reported as being damaged during the year, are inspected to determine how much they should produce. The field inspector reports this information to a higher agency official who decides on indemnization.

Up until 1973, the inspection at harvest time was made on all parcels belonging to the farmer reporting damage, not just the damaged parcel. This was because the insurance agency did not consider the insured unit as a single parcel, but as all parcels of the farmer concerned. Field inspectors, therefore, estimated the yields of all the parcels and took an average. If this yield was greater than the limit below which indemnization was paid, the farmer received no compensation, even though one of the parcels were a total loss. This procedure for determining indemnization has been the principal source of dissatisfaction with the service of the insurance agency among the farmers.

Aware of the farmers' attitude toward the insurance agency's procedure for approving indemnization, the Puebla Project staff consulted with the agency's director in 1972 about ways to resolve the problem. The insurance agency agreed to treat parcels separated by more than 1 km as separate insured units. This modified policy went into effect in 1973.

Crop Insurance Related Problems That Limit Farmer Use of Official Credit

Crop insurance in Puebla is seen as a major factor limiting farmer use of official credit. Although information collected in surveys indicates that farmers feel crop insurance is necessary in the region, the majority of them would not use it under present circumstances, if it were optional. As the farmers see it, the insurance agency is protecting the banks against losses, but not themselves.

To gain the confidence of the farmers in Puebla, changes must be made in the insurance agency's operating procedures. In addition, closer cooperation is needed with the credit banks and the Puebla Project, in coordinating effectively the field activities of agency inspectors, bank inspectors, and technical assistance agents. Several activities that could increase the effectiveness of the insurance agency are:

(a) informing the farmers of the crop insurance law: Most farmers have little or no knowledge of the crop insurance law, even about essentials such as the time period for advising the insurance agency in case of crop damage. However, field inspectors of the agency and banks, together with Project technicians, could provide instructions about the role of crop insurance, rights and obligations of the insured, and other operating procedures.

(b) defining the criteria for rejecting plantings because of "imminent risks": At the present time the insurance agency rejects plantings because of "imminent risks." Apparently, however, the reasons for rejecting such plantings are not well-defined. This creates dissatisfactions among farmers and can be avoided by precisely defining the nature of "imminent risks."

(c) informing the farmers promptly about the acceptance or rejection of their plantings and their right to indemnization. After the field inspectors look over a planting and prepare a report, farmers usually conclude that the planting is insured. This may or may not be the case, however, since the decision to accept or reject a planting is made in the Puebla office of the agency. Similarly, in the case of inspections at harvest time, farmers may erroneously conclude that their claim has been accepted when the inspector makes no statement to the contrary. It is important that farmers fully understand how decisions are made on these matters and that they be advised within a few days following inspections of the action taken by the insurance agency.

(d) developing a field inspection procedure that is more efficient for a highly fragmented area such as Puebla. Farmers in Puebla have an average of about 3 cultivated hectares distributed among three to four parcels that are often separated by a kilometer or more. Many of these parcels cannot be reached by vehicle; thus, the process of inspecting parcels is very laborious and expensive, resulting in long delays in making inspections and more problems for the farmer. Because of delays in inspections at harvest time, for example, the farmer may be required to postpone cutting and shocking his maize and plowing the land. As a result of such delays, farmers may not be able to plant early with residual moisture the following spring.

A procedure similar to that used by the original mutual crop insurance associations might be a possible solution to this problem. Each group would name a committee to inspect members' parcels and render a report. The agency field inspectors would make spot checks periodically to assure that the committees were observing the regulations of the insurance agency. A procedure similar to this is presently being used with good results by one group that receives credit from the Impulsora de Puebla.

(e) to cooperate more closely with the credit banks and the Puebla Project. The bank managers and the Project coordinator saw their relations with the director of the crop insurance agency gradually deteriorate during 1972 and 1973. The primary reason for this weakened relationship seems to be the questions asked by the Project staff regarding the operating procedures of the insurance agency. Near the end of 1972, for example, the Project coordinator invited the bank managers and the insurance agency director to work with him in finding a way to modify certain procedures of the insurance agency that were very troublesome to the farmers. The director of the insurance agency, however, showed little inclination to cooperate. The only accomplishment of the meeting was the decision to consider parcels separated by more than 1 km as different units for insurance purposes. Increased cooperation between the agency director and the representatives of other agricultural institutions in Puebla is essential to a more effective crop insurance program.

THE NATIONAL MARKETING AGENCY

The National Marketing Agency (CONASUPO) was established in 1962 with the following objectives: (a) to improve rural family income through support prices for different agricultural products; (b) to maintain reserves of basic foods with which to meet possible shortages; and (c) to regulate prices in consumer markets of basic foods to protect the low-income population.

Until 1971, CONASUPO purchased maize in the Puebla area and stored it in the central warehouses of the National Storage Agency (ANDSA). During 1968-1970, however, CONASUPO constructed rural warehouses at 15 locations throughout the Project area. Since 1971, CONASUPO has purchased maize at these warehouses without restrictions as to grain color or minimum quantity per producer. It has paid the official price of $75.20/ton for grain containing 14 percent moisture or less. Prior to the harvest in 1973, the official price was increased to $96/ton.

The purchasing procedure of CONASUPO is relatively simple. An employee receives the maize from the producer at the warehouse, weighs it, and determines the moisture content. If the grain contains more than 14 percent moisture, its weight is adjusted to that moisture content. A sales slip is prepared showing the weight of grain received and its value. The farmer presents the sales slip to the cashier and receives his payment.

One problem with this procedure, as far as farmers are concerned, is that the cashier is normally present at the warehouse only 2 days per week. This means that farmers often have to make a second trip to the warehouse in order to get paid. For this reason, and the inconvenience of having to haul their grain to the warehouse, most farmers continue to sell their maize to the village grain merchant. The network of CONASUPO buyers, nontheless, serves to keep the price paid by the local buyer from falling much below the official price.

Table 7.3 shows the amounts of maize purchased in 1971-1972 and 1972-1973 at the 15 rural warehouses, as well as the amounts sold to local consumers. Purchases in these 2 years account for a small part of the total maize sold in the area, indicating that most farmers sold to local buyers. The amounts purchased in 1972-1973 were much lower than in 1971-1972, probably because the price offered by local buyers that year was above $75.20/ton, due to a general shortage of maize throughout the country.

TABLE 7.3. Metric tons of maize purchased and sold by Conasupo at the rural warehouses in the Puebla area.

Name of warehouse	Purchases 1971-72	Purchases 1972-73	Sales 1971-72	Sales 1972-73
Magdalena	1463	675	7.4	18.7
Ocotitlán	141	45	- -	- -
Tlaxco	6485	3606	14.9	74.9
Coatepec	742	192	- -	56.6
Malacatepec	191	105	- -	96.8
Benito Juárez	1077	343	- -	67.7
Teotlalcingo	281	283	84.6	0.9
Tlautla	2660	1932	- -	13.1
El Verde	751	73	4.5	34.3
Acozautla	590	34	- -	2.6
Tepeaca	3643	1278	- -	210.7
San Andrés Cholula	1534	- -	- -	- -
Emiliano Zapata	- -	460	- -	29.1
Guadalupe Zaragoza	- -	20	- -	4.4
Santiago Coltzingo	- -	7	- -	- -
Total	19,558	9,053	111.4	609.8

8 EVALUATION PROCEDURES

INTRODUCTION

The Puebla Project was conceived as an experimental approach to develop and test strategies for rapidly increasing yields on small land holdings of subsistence farmers. Its operational strategies were designed to be flexible and subject to modification as new information was generated. Thus, provision was made for an evaluation unit with two main objectives: (a) to measure the progress made by the Project over time, and (b) to identify obstacles and collect the information needed for modifying strategies. Immediate feedback of this information to Project staff was a crucial step in developing remedial actions.

Consideration was given to contracting an independent agency to make the evaluation. There were two principal arguments in favor of this approach: (a) greater objectivity could be expected, as those involved in evaluation would have no direct personal interest in the success or failure of the Project, and (b) these more objective findings would probably carry more weight with policy makers.

There were also two important reasons for including evaluation as an integral part of the Project: (a) it would assure a continuous feedback of information to the other members of the Project team, and (b) obstacles limiting farmer participation could be identified and studied most effectively by an evaluation team working side by side with the members of the field staff.

After discussion of alternatives by Project members and advisors, evaluation was included as an integral part of the Project. In regard to the question of objectivity, it was felt that the essential conditions were objective criteria and adequate methodology, as in any research.

After the harvest of the fertilizer experiments in 1967, it became evident that the Project would begin promoting the use of revised maize technology in 1968. Thus, it was necessary to begin immediately to: (a) establish benchmarks on yield, technology of the farmers, level of living, etc. for future comparisons; (b) obtain information about the farmers and their present level of technology for use in planning the action program; and (c) obtain information on the infrastructure of the region—fertilizer distribution, agricultural credit, crop insurance, and price support programs.

COLLECTION OF EXISTING INFORMATION

Unpublished data for 1960 were obtained from the Census Bureau for the municipios in the Project area. These data provided a general idea of the area, the number of families living there, the total area planted to maize and the amount produced, and the size of the holdings.

Yearly data on area, production, and yield were available by municipios from the Dirección General de Economía Agrícola. The methods of data collection and yield estimation used by this agency were studied to determine whether such data would provide an adequate estimation of yield changes. This analysis suggested that a more precise measure of yield was needed to detect minor year-to-year changes.

To obtain the necessary kinds of estimates of both yield and characteristics of the farming population, a probability sample was chosen. This sample was used both for personal interview surveys and for yearly estimates of maize yields.

PERSONAL INTERVIEW SURVEYS

Survey: 1967

Farm operators of the Project area were the population of interest in this study. Because the Census lists were 8 years old, it seemed advisable to look for an alternative sampling frame. An area sampling technique turned out to be feasible because of the availability of aerial photos taken just 6 months earlier.

To keep costs at a reasonable level, a two-stage sample was drawn. The sample was selected as follows. Using a map of the region provided by the Mexican Defense Department, the Project area or was delineated. Next, 25 points were identified by locating coordinates with a list of random numbers. These points were then transferred to the aerial photos and a square 5 x 5 cm was drawn with the point as the center. This 25 cm^2 area was equal to 100 ha. These squares were then photographed and enlarged to a size which simplified identification of individual parcels and permitted more precise measurements of area.

The first stage of the field work involved locating the 25 segments and finding reference points—trees, roads, gulleys—that would help to identify individual parcels. Once the segment boundaries were established, the next step was to obtain the names of those who had operated each piece of land in 1967. The list of names of persons farming any land within the segment constituted the sampling frame for the second stage.

Random samples of the farmers in the area were interviewed in early 1968 and in mid-1971. The information collected in these surveys was used to describe the conditions existing at the beginning and to measure the changes that had occurred after the Project had been operating for three years.

The number of segments to be included in the sample and the number of farmers needed in each segment were estimated from the variability in two sets of data: (a) yields from the fertilizer trials planted throughout the area in 1967, and (b) yields measured on a sampling of farmers' fields in two municipios of the area in the fall of 1967. Based on these data, a 12 percent random sample was drawn among farmers in each segment to assure that 10 percent would be scheduled for interviews. A total of 251 farm operators were interviewed in the 25 segments.

Interviewers used a questionnaire that was pretested in December 1967. The questionnaire was designed to obtain information on: (a) types of farm ownership, (b) crop production, (c) livestock production, (d) farming costs, (e) tools and equipment, (f) composition of family income and its distribution, (g) crop production information at the farmers' disposal, (h) knowledge and use of modern agricultural inputs, (i) marketing of agricultural products, (j) existing organizations, (k) demographic and cultural characteristics of the farmer and his family, (l) living conditions of the farmer and his family, and (m) attitudes and expectations of the farmers about the future of agriculture.

After the 1967 pretest, the questionnaire was revised. Students, principally from the National School of Agriculture at Chapingo, conducted the bulk of the interviews during the 6-week period from January 2 to February 15, 1968.

The questionnaires were checked, and the information was coded and then punched on computer cards. The cards were computer processed, using specially designed programs to produce condensed tables. The card punching, programming, and processing were done at the Statistics and Computation Center of the Graduate College, Chapingo.

Survey: 1970

A second personal interview survey was conducted in the summer of 1971, referred to in this report as the 1970 survey because the data corresponded to events of 1970.

The main objectives of this study were: (a) to quantify the changes occurring between 1967 and 1970, (b) to examine factors that might have influenced these changes, and (c) to identify the factors that were favorable or unfavorable to the progress of the Project. Because comparisons had to be made over time, the questionnaire included the questions used in 1967, plus questions about variables not previously studied. The information collected in 1971 was designed to serve as a new benchmark for future studies.

Two categories of farmers were delineated in the Puebla area in 1971: (a) farmers on credit lists who were organized in groups, had received credit in 1970 from the institutions participating in the Project, and had ready access to information about the new maize recommendations; and (b) farmers not on credit lists who were not organized, did not receive credit from the participating institutions, and had limited access to information about the new recommendations. Two samples of farmers were interviewed in the 1970 survey: (a) farmers on credit lists and (b) all farmers in the area (a random sample of farmers from both the above categories).

The survey of farmers on credit lists involved a stratified random sample in which each stratum was made up of farmers who had received credit from one of the following: the National Agricultural Credit Bank, the National Ejidal Credit Bank, the Agricultural Bank of the South, and the

Impulsora de Puebla. This stratified sample was used because it was thought that there might be significant differences among the characteristics of the groups of farmers receiving credit from the four institutions.

The components of variance among and within the strata were estimated using the maize yields of farmers on credit lists in the 1970 season. (These yields had been estimated using an indirect procedure described on page 76). These components were used to determine the size of the sample necessary to estimate averages in maize yields with a 90-percent probability. There were 213 farmers in the sample.

A sample design in two stages, similar to that of 1967, was used for the survey of all farmers in the area. The components of variance among and within segments were estimated using the 1970 maize yields of all farmers in the area. The size of the sample of segments and number of farmers per segment were calculated using these components of variance, together with the quotient estimated in 1967 by dividing the average cost of identifying and taking a census of a segment by the average cost of interviewing a farmer. The number of segments was calculated at 25, but was increased to 31 to provide greater precision in the estimates. There were seven farmers per segment.

The sampling procedure used in 1967 assumed an unrestricted, random distribution of variables throughout the Project area. This random selection of segments, however, produced a pattern in which some parts of the area were sampled with greater intensity than others. Between 1967 and 1970, geographical trends in the distribution of variability were discerned in the area. These trends showed the assumptions of the 1967 sample to be faulty; the sample left large areas unrepresented, whereas other areas were sampled quite intensively.

Because of the above findings, plus the high costs involved in taking the census of segments, the following arbitrary scheme was developed for the first-stage sampling in 1970.

Twenty-one of the segments identified in 1967 were used in the 1970 survey. Ten new segments were added, located at random in parts of the area not adequately covered in 1967. Information about the Project area collected between 1967 and 1970 was used in delineating the 10 zones in which the new segments were located. The new segments were located in the field and the individual parcels identified.

A listing was made of all farmers who worked at least one parcel in the 31 segments. The sample of farmers was selected at random from these lists and interviews were made during the summer of 1971 by students from the National School of Agriculture at Chapingo, who had received 10 days of specialized training.

The completed questionnaires from the sample of farmers on credit lists and the sample of all farmers in the area were checked, and the information transferred to coded sheets. Data processing was done at the Statistics and Computation Center of the Graduate College, Chapingo.

STUDIES OF AGRICULTURAL INSTITUTIONS AND FARM SECTOR

Information relative to the infrastructure that had been collected through interviews with farmers was supplemented with data obtained directly from the agricultural institutions in special studies done in 1968 and 1973.

The 1968 study focused on the level of services provided by the credit banks, crop insurance company, and the marketing agency. In addition, the fertilizer distribution network was identified by compiling a list of all persons who sold fertilizer in the villages of the area.

The objectives of the 1973 study were: (a) to obtain a detailed understanding of the operating procedures and policies of the three official credit banks, the Impulsora de Puebla, and the crop insurance company; (b) to tabulate the amount of services provided by these institutions during the period 1965-1973; (c) to observe changes that had occurred in the operating procedures of these institutions in recent years; and (d) to determine to what extent such changes had been influenced by the Puebla Project.

Changes in the operating procedures of the institutions, and the amounts of services which they provided to farmers, were studied by gathering information directly from the institutions. Interviews were held with decision-makers, both in the office and field, and additional information was obtained from their files.

The Project farmers were interviewed in 1973 to obtain a better understanding of why many farmers were not following the Project recommendations. Among the specific issues covered in this study were: (a) the effect of farmer organizations on the adoption of the new technology, (b) the level of understanding by the farmers of the maize recommendations, and (c) the farmers' impressions of the efficiency of the services provided by the agricultural institutions.

The farmers interviewed in 1973 were located in 10 communities distributed throughout the five Project zones. These 10 communities were selected because they appeared to represent the area adequately in terms of the attention received from the Project technical assistance agents, and from the agricultural service institutions in Puebla. The first part of the study consisted of informal visits by the investigator to the communities over a period of 6 months to establish rapport with the villagers. In the second phase of the study a structured questionnaire was used to interview samples of: (a) farmers in organized groups, and (b) unorganized farmers. The first sample included 69 farmers, 35 of whom were group representatives and 34 were group members. The sample of unorganized farmers consisted of 29 heads of families in five communities where organized groups had functioned during the previous 3 or 4 years.

ANNUAL ESTIMATES OF MAIZE YIELDS

A major goal of the Puebla Project was to increase production per unit area of maize; thus, an accurate and continuing measurement of yields was crucial. Maize yields could be measured by selecting a random sample of fields in the area each year, with subsequent harvesting and measuring of grain yields. This method required locating the fields, locating the farmers (who usually lived some distance away in a neighboring village), obtaining permission to harvest the necessary sample area, harvesting in the presence of the farmer, and returning the grain to the farmer. All of the sample fields had to be harvested within a brief period–from maturity of the earliest plantings to the beginning of harvest by the farmers. These considerations prompted the search for a simpler method for estimating maize yields.

Development of an Indirect Method for Estimating Yields

In 1968, an estimation of maize yields was designed and conducted to provide data for developing a simple, indirect, reasonably precise method for estimating yields. In this process, the length of ear filled with grain, diameter of the unshucked ear at the base, and weight of grain with 12 percent moisture were determined for each ear in the maize fields included in a random sample. A prediction equation was developed by regressing grain yield-per-ear on the diameter and length of the ear. This prediction equation was used to prepare a table in which ear lengths were listed as row headings, ear diameters as column headings, with grain yields composing the body of the table. A rapid and reasonably accurate estimate of yield can be made with this table, using measurements of lengths and diameters of all ears in a sample area of a maize field.

This table has been used since 1969 for making annual estimates of maize yields in the Project area. A detailed description of the statistical procedures used in developing the regression model is given in an unpublished paper (Heliodoro Díaz C., Delbert T. Myren, and Richard E. Lund, "Estimating Corn Yields in the Puebla Area with a Regression Model Based on Ear Length and Diameter").

Estimation of Yields of All Farmers in the Area

An annual estimation of maize yields was made for two categories of farmers: (a) all farmers in the area and (b) farmers on credit lists. In 1971 and 1972, in addition to estimating yields, information was collected from the farmers on the use of technology in the parcels included in the samples.

A three-stage sample was used for estimating average yields of all farmers in the area. In the first stage, the segments selected for the 1967 and 1970 surveys were used. In the second stage, a random selection of parcels was made within the segments. In the third stage, five locations of 10 lineal meters each were chosen and distributed as shown in Fig. 8.1.

The components of variance among segments, among parcels, and within parcels were calculated annually, using the maize yields estimated in the evaluation of yields. There were 25 sample segments in 1968, 36 segments in 1969 and 1970, and 31 segments in 1971 and 1972. The number of locations within a parcel remained constant from year to year. The number of parcels per segment varied as a function of the magnitudes of the variances calculated for the previous season. The selection of parcels was made using a random systematic technique, with probability proportional to size; that is, a 4 ha parcel had four times as much probability of appearing in the sample as a 1 ha parcel.

After the parcels had been selected, the field was sampled as follows. First, a coin was flipped to determine direction of entry into the field. Then the number of rows was counted from left to right. Next, using a table of random numbers, the starting row was selected. In this row, 10 out of the first 20 meters were harvested, as shown in Fig. 8.1. Then the sampling was moved five rows to the right, progressively, until a total of 50 meters had been harvested. If this procedure carried the sampling to the outer edge of the field, as shown in Fig. 8.1, the procedure was begun again on the opposite edge and the counting of rows was resumed toward the right.

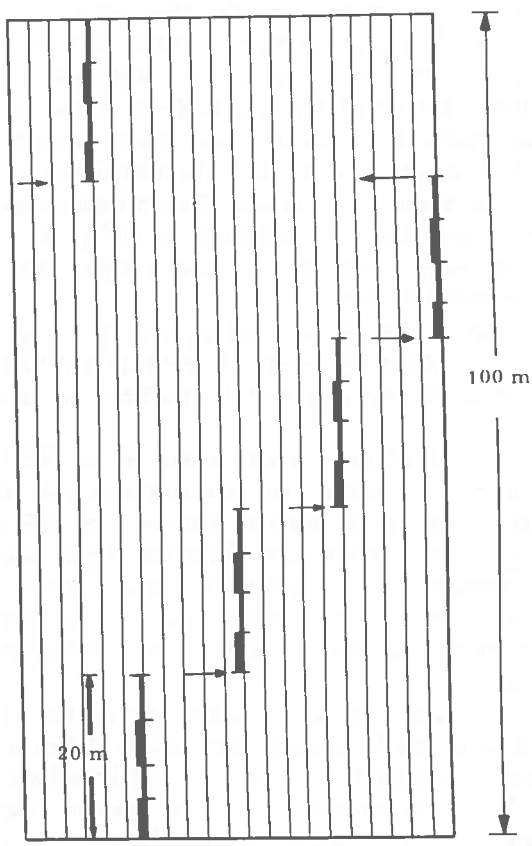


Fig. 8.1. The diagram shows the way in which the field was sampled for a total of 50 meters of harvested rows. From each 20 meters of row, two sections of 5 meters each were selected as shown.

In 1968, the yield estimate in each parcel was made by harvesting all the ears of maize within the 50 lineal meters. From 1969 onward, the yield estimate in each parcel was made using the indirect procedure described above.

Estimation of Yields of Farmers on Credit Lists

The average maize yield of the 103 farmers who used the Project recommendation in 1968 was estimated from yield measurements made on each farm. On farms where a farmer used the recommendations in two or more parcels, one parcel was selected at random for sampling.

In 1969 and 1970, a random sample in three stages was used for estimating the average maize yields. In the first stage, the credit groups were the population, and a sample of these groups was selected. In the second stage, a sample of parcels within groups was drawn from among all the parcels in selected groups for which the farmers had received credit for using the new technology. In the third stage, sites within the parcels were selected according to the scheme illustrated in Fig. 8.1.

In 1971 and 1972, the first step in estimating average maize yields was to divide the Project area into the five work zones described in Chapter 5. Lists were prepared, by zones, of all farmers on credit lists; farmers were randomly selected from the five lists. Among those farmers in the sample who received credit for using the recommendations on only one parcel, this parcel was chosen for sampling. Among farmers who received credit for two or more parcels, one parcel was selected at random. Sites within parcels were selected as shown in Fig. 8.1. The number of farmers per zone in the sample was determined from variances calculated from estimates of yield made during the previous year for each zone.

After the sites within parcels were selected, the estimation of yield was made using the indirect procedure described on page 76.

Comments on the Evaluation Program

Some deficiencies in the operation of the evaluation program are now apparent. As mentioned, a primary concern of evaluation was to quantify the Project's progress, and primary emphasis was placed on the socioeconomic surveys, the annual estimates of yield, and the use of this information for evaluating change. As a result, much less importance was given to identifying obstacles limiting farmer use of the new technology and in studying means to overcome these barriers. Thus, the Project was sometimes slow in modifying its operational strategies, particularly with respect to farmer organizations and the service institutions.

This deficiency could be overcome by arranging for an evaluation staff to receive assistance from highly trained consultants with a broad understanding of evaluation. It may also be necessary to increase the resources allocated to evaluation and to provide the staff with additional training.

Another evaluation deficiency related to the rate at which the collected and processed data was fed back to the rest of the Project staff. Data on yield and the use of technology collected each year at harvest time were generally

An indirect method was developed in 1968 for estimating the average maize yield in the project area just prior to harvest. Measurements of the lengths, diameters and weights of all ears from a large number of plots were used to calculate a regression equation. Using this relationship, yields were estimated in subsequent years by measuring ear lengths and diameters in a selected area of a random sample of fields.

made available within 2 months after the surveys were completed. Information from the 1970 socioeconomic survey, on the other hand, was not made available to the staff until early 1973. This was due to a series of problems related to coding, programming, and data processing that could probably have been avoided with additional technical assistance.

Two methodological problems arose in evaluation; one of these stemmed from use of the variance of maize yields as the basis for estimating the sample size used in the surveys. Since the objective of the surveys was to measure many characteristics of the farmer, his family, and farm, it would have been more appropriate to use the variance of a more inclusive variable, such as total family income, in estimating sample size.

A second methodological problem arose in selecting the segments for the 1970 survey of all farmers in the area. The arbitrary scheme that was followed was thought to offer a better representation of the Project area. This scheme, however, led to difficult theoretical problems in hypothesis testing, inasmuch as there appeared to be no appropriate way to estimate the variances of the statistics of the 1970 survey. Thus, two alternatives were available for analyzing the changes that occurred in the area from 1967 through 1970: (a) to consider only the 21 common segments of the two surveys. In this case, variance estimation would be easy to compute and hypothesis testing would be straight forward. However, the aggregated area of the 21 segments, rather than the total Project area, would become the population to which direct inferences could be made. Inferences about the total Project area would have to be guided by past experience and general knowledge; (b) to consider all the information collected from the 25 segments in 1967 and the 31 segments in 1970 in making inferences about the total Project area. In this case, it would not be appropriate to test hypotheses about population parameters. Again, past experience and general knowledge would play a role in comparing the statistics.

It was decided to adopt the second alternative for this report. Thus, no variances or confidence intervals are presented in the chapters where data from the 1967 and 1970 surveys are compared.

As mentioned, methods used for selecting the segments used in the estimation of yields of all farmers in the area differed from 1968 to 1969-1970, and to 1971-1972. This should be taken into account in studying the yield data in Table 9.8.

9 FARMER ADOPTION OF MAIZE RECOMMENDATIONS

INTRODUCTION

As described in Chapter 3, new recommendations on the production of maize were available at the beginning of 1968, and these recommendations were modified for subsequent years, particularly for certain parts of the area and for late dates of planting. Promotion of the use of these recommendations was begun in 1968 with 103 farmers, and was extended throughout Zones I, II, III, and IV in 1969, and to the remainder of the area in 1970.

In general surveys in 1967 and 1970, the Project evaluation team obtained information useful for estimating the extent to which the recommendations of the Puebla Project have been used by the farmers in the area. Similar information was obtained for the 5 years from 1968 to 1972 when the evaluation team estimated maize yields just prior to harvest and obtained interviews with the farmers whose fields were sampled. This chapter presents some of these data: (a) to show the degree to which farmers have used the recommendations, and (b) to compare average maize yields during 1967 to 1972. A final section discusses the influence of certain factors on farmer adoption.

LEVEL OF ADOPTION OF THE MAIZE RECOMMENDATIONS

Quantitative discussion of the level of adoption of the new maize recommendations is complicated by several factors: (a) there was an initial tendency for farmers to only partially adopt an individual production practice. For example, instead of changing from a traditional level of 30,000 plants/ha to a recommended level of 50,000, the farmer often changed to some intermediate level; (b) farmers often tended to accept some recommended practices more readily than others; that is, they might increase their rate of nitrogen fertilization before changing the way they apply it; and (c) farmers often tended to use the new technology initially on only a portion of their land.

Thus, the evaluation of the level of adoption became a matter of determining the percentages of farmers who were using the various recommended practices in different degrees at different times. Such evaluation in the Puebla area was hampered by the diversity in recommendations that had evolved over the years. By 1972, specific maize recommendations were available for 16 producing conditions. Recommended rates of nitrogen varied from 60 to 130 kg/ha for rainfed maize, rates of phosphorus from 0 to 60 kg P_2O /ha, and plant densities from 30,000-50,000 plants/ha. The information collected for measuring adoption rate, however, was taken from a sample of farmers selected at random from the Puebla area as a whole, or from the five geographical zones where the technical assistance agents were assigned. Thus, information was not available for individually evaluating the level of adoption of the specific maize recommendations for the 16 producing systems.

Lacking the above information, it was decided to establish arbitrary ranges in values of the several recommended practices, corresponding to high, intermediate, and low levels of adoption and apply them to the entire project area. These ranges are shown in Table 9.1. The lower limits for high levels of adoption of nitrogen, phosphorus, and plant density--80 kg/ha, 30 kg/ha, and 40,000 plants/ha, respectively--are the lowest rates of these inputs that were being recommended in the area in 1973; except in the case of nitrogen, for one producing system with a very low production potential and a second system with plantings made immediately following alfalfa; and, in the case of phosphorus, for the two producing systems in Zone V for which no phosphorus is recommended). (The limits between high and intermediate levels of adoption were established as a function of the recommendations for unlimited capital (Chapter 3). Thus, many of the farmers in intermediate category can be considered high adopters in terms of Project recommendations for limited capital.) The upper limits for the low levels of adoption correspond approximately to rates used by farmers who were making most intensive use of fertilizers in 1967. The phosphorus ranges for Zone V are different from the rest of the area because phosphorus has not been recommended for that region since 1970.

TABLE 9.1. Ranges in rates of nitrogen, phosphorus and plants per hectare corresponding to high, intermediate and low levels of adoption of the three practices.

Level of adoption	Nitrogen (kg/ha)	Phosphorus (kg/ha of P_2O_5) For Zones I,II,III,IV	For Zone V*	Plant density (thousands per ha)
Low	0-50	0-20	> 30	0-30
Inter.	51-80	21-30	11-30	30-40
High	> 80	> 30	0-10	> 40

* The ranges in rates of phosphorus corresponding to the three levels of adoption are reversed for Zone V, since phosphorus is not recommended for maize in that region.

Most of the available information on the levels of use of nitrogen, phosphorus, and plant density refers to a random sample of parcels for the Project area. In general, therefore, the analysis made here refers to the *percentage of parcels* with a certain level of adoption of the recommended practices. If farmers were to use the new technology uniformly on all their parcels, then the percentage of parcels with a given level of adoption should be similar to the percentage of farmers with the same level of adoption. However, in the Project, where the farmers had an average of slightly over three parcels and tended to adopt the new technology initially on only a part of their land, it was expected that percentages calculated in terms of parcels would be lower than percentages calculated in terms of farmers for a given level of adoption. This assumption was substantiated by estimating (from the survey data for 1967 and 1970) the percentages of farmers with a high level of adoption of nitrogen and phosphorus, and comparing them with percentages of parcels with high levels of use of the two practices.

Analysis here is in terms of the average amounts of nitrogen, phosphorus, and plants per hectare and to the percentages of parcels on which these practices were used at high, intermediate, and low levels. The available information with respect to time of applying fertilizers, weed control, and insect control was not sufficient for drawing conclusions about changes in farmer use of these practices.

All Farmers in the Area

The 1967 survey involved a random sample of all the farmers in the Project area. The 1970 survey, as well as the yield evaluations for the years from 1968 to 1972, involved a sample of all farmers in the area and another sample of farmers on credit lists. (These farmers were organized into groups and were aided by the technical assistance agents in arranging for credit and in using the new technology properly.) The data from the sample of all farmers provide the relevant information on the level of adoption of the recommendations for the Project area and are presented first. The use of the recommendations by the farmers on credit lists is discussed later.

The average rates of nitrogen and phosphorus and average plant densities for maize plantings in the Puebla area for the period 1967-1972 are shown in Table 9.2.

TABLE 9.2. The average amounts of nitrogen and phosphorus in kilograms per hectare and the average number of plants in thousands per hectare used in maize plantings in the Project area from 1967 to 1972.

Practice	1967	1968	1969	1970	1971	1972	% increase*
Nitrogen	34	..	..	53	83	78	129
Phosphorus (P_2O_5)	14	..	..	19	30	27	93
Plant density	..	31	31	33	33	34	10

* The difference between the values in 1972 and the first year with information, expressed as a percentage of the value for the first year.

From 1967 to 1972, the average increases were: nitrogen, 129 percent; phosphorus, 93 percent; and plants/ha, 10 percent. The increase in nitrogen use is remarkable and reflects the farmers' general awareness of the need to apply large amounts of this fertilizer. The slightly smaller change in the average application of phosphorus is due in part to the recommendation that farmers use no phosphorus for maize in Zone V.

The small change in average plant densities is believed to be due to one or more of the following reasons: (a) farmers are often uncertain at planting time whether they will obtain all the fertilizer they need; they use a rate of seeding lower than that recommended with the idea that the maize will produce better at the lower plant density, should they not obtain sufficient fertilizer; (b) farmers are concerned about drought and believe their maize will do better, in case of drought, if the plant density is low; and (c) the farmers' major concern is in increasing their production of large ears, and they feel this can best be achieved with plant densities below the recommended levels. All of these reasons have a certain validity and provide an excellent example of how difficult it is to convince low-income farmers in rainfed areas to radically change their technology, and how difficult it is to develop and deliver recommendations that are adequate for the extremely variable production and economic conditions of the farmers.

The levels of adoption of the recommended rates of nitrogen, phosphorus and plant density can also be examined in terms of changes in the percentages of parcels with high, intermediate, and low levels of use of these practices. Table 9.3 shows the information needed for this analysis for the period 1967-1972. During this time, the percentages of parcels with a high level of adoption of the three practices increased; whereas, the percentages of parcels with a low level of adoption decreased, and the percentages of parcels in the intermediate category remained constant.

In 1972, the percentages of parcels with a high level of adoption of each of the three practices were about equal, varying from 44.8 percent for nitrogen to 39.4 percent for plant density.

From 1967 to 1972, the increase in the percentage of parcels with a high level of adoption of the nitrogen recommendation (37.4 percent) was much greater than the increases for the phosphorus (20.6 percent) and plant density (25.4 percent) recommendations. This finding again suggests that the farmers in the area have accepted the nitrogen recommendation more readily than the phosphorus and plant density recommendations. The 25.4 percent change in the percentage of parcels with a high level of adoption of the plant density recommendation indicates a greater acceptance of this recommendation than was suggested by the increase of only 10 percent in the average plant density for all plantings in the area.

Since there is usually a positive interaction among the production factors in their effects on maize yields, the maximum increase from a package of production practices is obtained when all factors are used at the recommended

TABLE 9.3. Percentages of parcels in the Project area with high, intermediate and low levels of adoption of the nitrogen, phosphorus and plant density recommendations.

Practice	Level of adoption	Year 1967	1968	1969	1970	1971	1972	Change*
Nitrogen	High	7.4	–	–	33.1	33.6	44.8	+ 37.4
	Intermediate	11.0	–	–	14.0	15.0	14.0	+ 3.0
	Low	81.6	–	–	52.9	51.4	41.2	– 40.4
Phosphorus	High	23.7	–	–	38.4	44.4	44.3	+ 20.6
	Intermediate	7.7	–	–	9.2	6.1	9.1	+ 1.4
	Low	68.6	–	–	52.4	49.5	46.6	– 22.0
Plant density	High	–	14.0	15.8	24.9	23.8	39.4	+ 25.4
	Intermediate	–	35.2	34.0	30.8	29.0	33.9	– 1.3
	Low	–	50.8	50.2	44.3	47.2	26.7	– 24.1

* Change is the difference in the values for 1972 and the first year in which information was available.

TABLE 9.4. Percentages of parcels in the Project area with all combinations of high, intermediate and low levels of adoption of the nitrogen and phosphorus recommendations.

Levels of adoption	1967 (N=337)*	1970 (N=713)	1971 (N=214)	1972 (N=221)
High for both practices	4.8	20.7	19.6	29.9
High for one; intermediate for the other	7.7	10.5	12.2	6.8
High for one; low for the other	13.9	19.4	26.6	22.6
Intermediate for both practices	0.3	1.0	0.0	0.9
Intermediate for one; low for the other	10.4	10.8	8.9	14.5
Low for both	62.9	37.6	32.7	25.3

* N is the number of parcels in the sample.

levels. It is enlightening, therefore, to examine the degree to which the nitrogen, phosphorus, and plant density recommendations have been adopted simultaneously.

Information is available for 1967, 1970, 1971, and 1972 on the percentages of parcels with all combinations of the three levels of adoption of the nitrogen and phosphorus recommendations. Table 9.4 shows the percentage of parcels with high levels of adoption of both nitrogen and phosphorus increased from 4.8 percent in 1967 to 29.9 percent in 1972. The percentage of parcels with a low level of adoption of both practices decreased during the same period by a larger amount, from 62.9 percent down to 25.3 percent.

Information on the percentages of parcels with the three levels of adoption of the nitrogen, phosphorus, and plant density recommendations is available for 1971 and 1972 only. Table 9.5 shows a high level of adoption of the three practices on 10.4 percent of the parcels in 1972. There was a high level of adoption of at least two of the practices on 41.2 percent of the parcels in the same year.

The data in Tables 9.3 through 9.5 show a relatively high percentage of the parcels with a high level of adoption of individual recommended practices, a lower percentage of parcels with a high level of adoption of the nitrogen and phosphorus recommendations, and a still lower percentage of the parcels with a high level of adoption of the three practices. This indicates that most farmers in the Puebla area are presently not realizing the full potential of the increased production that comes from using all the production practices at the recommended levels. Clearly, the job of adjusting and delivering adequate technology, as well as that of inducing farmers to use the recommended technology, is very difficult, and is far from being accomplished in the Puebla area.

TABLE 9.5. Percentages of parcels in the Project area with different combinations of high, intermediate and low levels of adoption of the nitrogen, phosphorus and plant density recommendations.

Levels of adoption	1971 (N = 214)*	1972 (N = 221)
High for the three practices	3.4	10.4
High for two; intermediate for one	6.5	11.3
High for two; low for one	21.0	19.5
High for one; intermediate for two	3.7	2.7
High for one; intermediate for one; low for one	15.9	15.4
Intermediate for the three practices	0.0	0.9
Intermediate for two; low for one	3.7	5.9
High for one; low for two	17.3	17.6
Intermediate for one; low for two	12.6	10.4
Low for the three	15.9	5.9

* N is the number of parcels in the sample.

Farmers on Credit Lists

Farmers on credit lists receive credit for purchasing the inputs, mainly fertilizers, required for the recommendations of the Puebla Project. The technical assistance agents provide information about amounts of fertilizers to apply, when and how to apply them, the seeding rate, and other recommended practices. As a group, farmers on credit lists would be expected to use the recommendations of the Puebla Project most efficiently.

Table 9.6 shows the numbers of farmers on credit lists and the corresponding areas of maize for which credit was received during the years 1968 to 1973. As noted previously, both the number of farmers and the area for which credit was received increased rapidly in 1969 and 1970, with a slower rate recorded for the following 3 years. In 1973, 16.6 percent of all the farmers in the Puebla area received credit for the production of maize according to Project recommendations, representing 25.8 percent of the total harvested area of this cereal. (Thus, the percentage of the area for which credit was received is about 50 percent greater than the percentage of farmers receiving credit. This, however, does not necessarily imply that the larger farmers have greater access to credit. It is known, for example, that some farmers include the needs of other members of their family in their request for credit.)

TABLE 9.6. The number of farmers on credit lists and the areas of maize for which credit was received in 1968-1973.

Year	No. of farmers	% of total*	Area ha	% of total**
1968	103	0.2	76	0.1
1969	2561	5.9	5838	7.3
1970	4833	11.1	12601	15.8
1971	5240	12.1	14438	18.0
1972	6202	14.3	17533	21.9
1973	7194	16.6	20604	25.8

* Based on a total of 43,300 farmers.

** Based on a total of 80,000 ha of maize.

Table 9.7 shows the percentages of parcels of farmers on credit lists with high, intermediate, and low levels of adoption of the nitrogen, phosphorus, and plant density recommendations. The percentages for nitrogen and phosphorus in 1971 and 1972, and the percentages for plant density for all years refer specifically to parcels for which credit was received. The percentages for nitrogen and phosphorus in 1970 refer to *all* parcels of the farmers on credit lists. The differences between 1970 and 1971 in the adoption of the nitrogen and phosphorus recommendations probably overstate the change in adoption occurring that year; they also indicate that some of the farmers on credit lists apply the recommended practices on only a part of their parcels.

In 1971 and 1972, about 75 to 80 percent of the parcels of farmers on credit lists for which credit was received showed a high level of adoption of the nitrogen and phosphorus recommendations; judgment of the adequacy of this level of adoption of the fertilizer recommendations by farmers on credit lists should take into account that five technical assistance agents were assisting 5,240 farmers in 1971 and 6,202 in 1972.

In 1968, 82 percent of parcels of farmers on credit lists showed a high level of adoption of the plant density recommendation; this figure declined to 36.1 percent in 1970 and has remained fairly constant. The high level of use of the plant density recommendation in 1968 was due to the close supervision (particularly at planting time) of the 103 farmers on credit lists by one full-time and one part-time technical assistance agent. The percentage drop in 1969 and again in 1970 probably reflects the rapid increase in the number of farmers on credit lists and the resulting decline in the assistance that could be given to each farmer. The low percentage of parcels in 1970 through 1972 with a high level of adoption of the plant density recommendation

TABLE 9.7. Percentages of parcels of farmers on credit lists with high, intermediate and low levels of adoption of the nitrogen, phosphorus and plant density recommendations.

Practice	Level of adoption	Year					
		1968	1969	1970	1971	1972	Change*
Nitrogen	High	—	—	51.1	72.9	75.8	+ 24.7
	Intermediate	—	—	25.5	19.9	17.7	- 7.8
	Low	—	—	23.4	7.2	6.5	- 16.9
Phosphorus	High	—	—	64.4	82.3	76.6	+ 12.2
	Intermediate	—	—	7.6	5.0	9.7	+ 2.1
	Low	—	—	28.0	12.7	13.7	- 14.3
Plant density	High	82.0	55.7	36.1	29.8	37.1	- 44.9
	Intermediate	18.0	34.4	28.7	28.7	34.7	+ 16.7
	Low	0.0	9.9	29.0	41.5	28.2	+ 28.2

* Change is the difference in the values for 1972 and the first year in which information was available.

indicates the previously discussed (page 80) reluctance of the farmers in the Puebla area to use high plant populations. Perhaps this reluctance is a reflection of the fact that information received by the farmer is imperfect, or that the farmers adjust the recommendations in terms of their perception of application to their local conditions.

CHANGES IN AVERAGE MAIZE YIELDS

Information on average maize yields in the Puebla area was available for the years 1967 through 1972. Estimations of yield were made directly in the field from 1968 to 1972, using the method described in Chapter 8. Maize yields also were estimated for 1967 and 1970 from information collected from farmers in the surveys, taking into account all the parcels on which the interviewed farmers grew maize.

The average maize yields for all farmers in the area and for farmers on credit lists are shown in Table 9.8. Using 1968 as a base, the changes in average yields for the following years were calculated and are shown in the table as percentages. The year 1968 was used as a base, rather than 1967, because it was felt that the Puebla Project could not have influenced the general average for 1967 and because all estimations of yields were made in the same way beginning in 1968.

The average maize yields for farmers on credits lists (Table 9.8) varied from 3,985 kg/ha in 1968 to 2,679 kg/ha in 1971. The high average in 1968 can be attributed to very favorable rainfall conditions, and to the fact that the yields of only 103 carefully selected farmers (who received close supervision by the technical assistance agents) entered into the calculation. The average yields of farmers on credit lists varied little from 1969 through 1972.

The average maize yields for all farmers in the area have varied from 1,330 kg/ha in 1967 to 2,499 kg/ha in 1972. Comparing only the average yields for the first and the last years, it is seen that the average yield increased by 88 percent. This, however, overestimates the real increase in maize

TABLE 9.8. Average maize yields* for all farmers in the Puebla area and for farmers on credit lists.

	All farmers in the area		Farmers on credit lists	
Year	Average yield kg/ha	% change compared to 1968	Average yield kg/ha	% change compared to 1968
1967	1330			
1968	2140	base	3985	base
1969	1832	-14.4	2829	-29.0
1970	1962**	- 8.3	2732	-31.4
1971	1927	- 9.9	2679	-32.8
1972	2499	÷16.8	2920	-26.7

* Grain with 14%moisture. The value for 1967 was calculated from information provided by farmers in the survey; values for the other years were calculated from field measurements made just prior to harvest.

** The average yield for 1970, calculated from the survey data, was 1864 kg/ha.

yields in the area, because rainfall conditions were much more favorable in 1972 than in 1967.

In a rainfed area like Puebla, average maize yields in a given year are determined largely by the climatic conditions that prevail and the production technology that is used. To estimate the effect of the new technology on average yields in the Puebla area, it is necessary to adjust the average yields in Table 9.8 by eliminating the effect of climate.

Two methods have been used to estimate the percent increase in average maize yields of all farmers in the area due to use of the production practices recommended by the

Average maize yields for the project area were adjusted for the effects of climate using yield data from fertilizer rate experiments conducted each year in the area. The yields of plots receiving a uniform treatment in the several experiments conducted each year were averaged, and the variation in these yearly averages was assumed to be due to climatic differences.

TABLE 9.9. An estimation of the increase in average maize yields in the Puebla area due to the use of the recommended production practices, in which the effect of climate is calculated from experimental data.

Year	(a) Average yield for all farmer kg/ha	(b) Estimation of the effect of climate (%change compared to 1968)*	(c) Estimated yields assuming no change due to new technology** kg/ha	(d) Differences in yield in kg/ha attributable to new technology (a-c)	(e) % increase in average yields attributable to new technology ($\frac{d}{c}$ x 100)
1967	1330	-	-	-	-
1968	2140	-	2140	0	-
1969	1832	-18	1755	+ 77	4.4
1970	1962	-15	1819	+143	7.9
1971	1927	-21	1691	+236	14.0
1972	2499	- 6	2011	+488	24.2

* These percentages were calculated from the average yields obtained in the field experiments with the treatment consisting of 50 kg/ha of nitrogen, 25 kg/ha of P_2O_5 and 30 thousand plants per hectare.

** 2140+(the value in column b) (2140), where 2140 is the average yield in 1968.

Puebla Project. The first of these involves the use of yield data from the fertilizer rate experiments conducted each year in the Project area. Data were available from 8 to 12 experiments in each of the years from 1968 to 1972. Average yields were calculated for the plots in the several experiments receiving 50 kg/ha N, 25 kg/ha P_2O_5, and 30,000 plants/ha. (This treatment was used because it produced average yields similar to those for all farmers in the area. Since an interaction can be expected between production level and climatic effects, it was desirable that the average levels of production of the selected treatment and all the farmers be similar.) The changes in these average yields with respect to 1968 were calculated for the years 1969-1972. Shown in column b, Table 9.9, these changes, expressed as percentages, are estimations of the effect of climate. These percentages were multiplied by the average yield in 1968 to obtain the differences in yield due to climatic effects. Then, the differences in yield due to climate were added to the average yield in 1968 to obtain the average annual yields unaffected by the new technology, as shown in column c, Table 9.9.

The differences between the average yields for all farmers and the estimated yields assuming no effect of the new technology were considered to be the effects attributable to the use of the new technology. These differences are shown as percentages in column e, Table 9.9.

As shown in Table 9.9, estimated increases in average yields of all farmers in the area varied from 4.4 percent in 1969 to 24.2 percent in 1972. This method for adjusting average yields for the effect of climate has obvious deficiencies. The number of experiments that provided the data for this calculation was too small to sample the area adequately. Also, these experiments were not distributed over the Project area so as to give proper weight to the 16 producing systems.

The second method for adjusting average yields for the effect of climate used the information obtained in the objective yield measurements of samples of farmers on credit lists. It was assumed that those farmers on credit lists with yields in the upper third of the sample had used the recommended technology quite adequately, and that this level of use of the technology had been reasonably constant over the years. It was further assumed that (for a given year, using 1968 as a base) the change in the average yield for the upper third of farmers on credit lists was a measure of the relative favorableness of the climate for that year.

This method was used to estimate the effects of climate for the years 1969-1972 with the results shown in column b, Table 9.10. Data for farmers on credit lists in Zone V were not included in this calculation, because the Puebla Project did not begin to promote the use of new technology in that region until 1970. The estimated combined effects of climate and use of the new technology (Table 9.8) are reproduced as percentages in column c, Table 9.10. The percentage increases in yield with respect to 1968 attributable to the use of the recommended practices, shown in column d of Table 9.10, were calculated by subtracting the effect of climate, (column b) from the combined effects of climate and technology (column c). The estimated increases in yield due to use of the new technology (column f) were calculated by multiplying the percentage increases in column d by the average maize yield in 1968. The average yields without the new technology were estimated (column g) by subtracting the increases in column f from the average yields for the area in column e. The increases in yield due to the new technology, expressed as a percentage of the average yields without the technology, are shown in column h.

According to this second method of adjusting average yields for the effect of climate, estimated increases in aver-

TABLE 9.10. An estimation of the increase in average maize yields in the Puebla area due to the use of the recommended production practices, in which the effect of climate is calculated from the maize yields of farmers on credit lists.

Year	(a) Average yield of the upper 1/3 of farmers on credit lists kg/ha	(b) Estimation of the effect of climate (%change compared to 1968)	(c) Estimation of the effect of climate plus technology (%change compared to 1968)*	(d) Estimation of the effect of technology (c-b) (%change compared to 1968)	(e) Average yields for area kg/ha	(f) Estimated increase in yield due to technology** kg/ha	(g) Estimated average yield without the technology (e-f) kg/ha	(h) %increase in average yields attributable to technology ($\frac{f}{g}$ x 100)
1968	4965	base	base	-	2140	-	2140	
1969	4090	-17.6	-14.4	+ 3.2	1832	68	1764	3.9
1970	4085	-17.7	- 8.3	+ 9.4	1962	201	1761	11.4
1971	4043	-18.6	- 9.9	+ 8.7	1927	186	1741	10.7
1972	4087	-17.7	+ 16.8	+ 34.5	2499	738	1761	41.9

* From Table 9.8
** Percentage in Column (d) multiplied by the average yield in 1968.

age yields of all farmers in the area varied from 3.9 percent in 1969 to 41.9 percent in 1972. This method also has obvious limitations. The average use of the new technology by the upper third of farmers on credit lists may have been higher in 1968, than in other years. Or, stated more generally, there is no empirical basis for assuming that the use of technology by the upper third of farmers on credit lists was reasonably constant. It is also possible that the upper third of farmers on credit lists does not provide a representative sample of the producing conditions in the Puebla area.

The two methods for estimating the increases in maize yields attributable to the use of the new technology give similar percentages for 1969, 1970, and 1971, but differ markedly for 1972. It is probably reasonable to assume that the true percentage increase in average yields due to the new technology is somewhere near the average of the values obtained with the two methods. This calculation would suggest that average maize yields in the Puebla area probably increased through the use of improved technology by about 30 percent from 1967 to 1972.

The above efforts to adjust average maize yields for the effect of climate indicate the need for a project to develop plans from the outset for collecting the data required for such an adjustment. Experience in the Puebla Project suggests that the necesary data can be generated by making simple plantings, consisting of three plots managed at low, medium, and high production levels, at sites distributed throughout the Project area. The number of sites required would be determined as a function of the variability among sites, and these would be located adequately to sample the different producing systems in the Project area. The same general sites (but not the exact site) and plot treatments would be used each year. If sufficient information were not available the first year to accurately establish the limits of the several producing systems, the number of sites should be increases initially by perhaps 100 percent to assure that each system was adequately sampled. It should be possible at a later date (once the limits of the producing systems were defined) to reduce the number of sites to those necessary, based on the variability among sites and the level of precision desired. Annual differences in the average yields for each of the treatments should provide a reliable estimate of the effects of climate.

FACTORS INFLUENCING THE ADOPTION OF THE MAIZE RECOMMENDATIONS

Some information on the adoption of the maize recommendations, such as the number of farmers on credit lists (Table 9.6), suggests a rapid rate during 1969 and 1970 and a somewhat slower rate for the next 3 years. The information on the increases in average yields attributable to the new maize technology (Tables 9.9 and 9.10), on the other hand, indicates an accelerated rate of adoption in 1972. Based on the available information, it seems reasonable to conclude that there has been a fairly continual rate of increase in the use of the Project recommendations since 1969.

This increase in the use of the new maize technology has produced an increase in average maize yields that has been estimated to be around 30 percent over the 4-year period 1969-1972, or about 7.5 percent per year. There seem to be no valid yardsticks for judging whether this is a reasonable rate of progress for a rainfed area with a moderate level of agronomic risk. It is evident, however, that many farmers at the end of 1972 were not using the recommendations (41 percent of parcels with a low level of adoption of the nitrogen recommendation, Table 9.3), and others were only using them partially (75 percent of parcels with a low level of adoption of one or more of the three main practices, Table 9.5). Thus, it seems appropriate to ask why the rate of adoption has not been faster and to examine some of the reasons farmers have continued to use their traditional practices.

Availability of Information

In promoting the use of the Project's new recommendations, the technical assistance agents also told the farmers how to apply them; what they would cost to use; the expected increases in production and net income from their use in good, average, and poor years; and the importance of using each practice at the recommended level. It was assumed that the farmers (particularly those who provide the leadership for the community) would require full knowledge of the new technology to make accurate appraisals.

In examining the extent to which information on the Project recommendations has been disseminated throughout the Puebla area, it is important to distinguish between: (a) a simple understanding of what the recommendations are and (b) full knowledge of how to use them and of the expected returns in terms of increased production and net income.

Relevant data on farmers' knowledge of the recommendations was collected in 1973, in a study of farmers not on credit lists in five communities where groups of farmers organized by the Puebla Project had functioned for 3 or 4 years. Of the 29 farmers interviewed, 26 (90 percent) had heard of the maize recommendations of the Puebla Project. Only 15 (52 percent) of the 29 farmers, however, were convinced that the use of the maize recommendations would result in higher yields.

These data suggest that by 1973 most of the farmers in the Puebla area had heard of the new maize recommendations. A much smaller percentage, however, perhaps around 50 percent, had received information sufficient to persuade them that the new technology would increase yields. The low level of use of one or more of the three main practices on 75 percent of the parcels in 1972 (Table 9.5) suggests that perhaps 25 percent or less of the farmers understood the more complex aspects of the new technology, such as the importance of using *all* of the recommended practices at the recommended levels. Clearly, the Project recommendations have not been completely understood by the farmers, thus preventing their full realization of the potential benefits of the new technology.

Adequacy of the New Technology

Another interpretation can be made regarding the 48 percent of the farmers in the 1973 survey who were not convinced of the usefulness of Project recommendations: that rather than an indication of the lack of adequate information, it could be that the new technology is, in fact, not superior to the traditional practices. Certainly, lack of adequate technology has been a notable weakness of many programs seeking to improve agricultural production in rainfed areas.

The adequacy of the maize recommendations of the Puebla Project was examined in some detail in Chapter 3. Table 3.11 shows that producing systems 1.1.1, 2.1.1, and 3 (which account for 53 percent of the cultivated area in maize) had estimated average maize yields using the traditional technology of: 2.05 ton/ha (1.1.1); 2.15 ton/ha (2.1.1); and 2.56 ton/ha (3). The estimated average yields using the Project recommendations for unlimited capital were 3.80 ton/ha (1.1.1); 3.87 ton/ha (2.1.1); and 3.64 ton/ha (3). For the entire Project area, the estimated average yields were 2.05 ton/ha using traditional practices and 3.13 ton/ha using the Project recommendations for unlimited capital.

The estimated net incomes from using the traditional and Puebla Project technologies, expressed in kg/ha of maize, are shown in Table 3.13. The estimated net incomes using the two Project recommendations are larger than the estimated net incomes using the traditional practices in each of the 16 producing systems. For the entire area, the estimated net incomes using the Project recommendations were 51 percent greater for limited capital and 95 percent greater for unlimited capital, as compared to the estimated net incomes using the traditional practices.

Another indication of the adequacy of the Project recommendations is that most farmers, after they have used the new technology, apparently continue to use it in the following years. This is a reasonable conclusion to draw from the findings that both the level of use of the recommendations and the average maize yield in the area have increased at a fairly constant rate during the period 1969-1972. Had a significant proportion of the farmers in the area realized lower net incomes because of inadequacy of the new technology, it seems reasonable that the use of the recomendations and the average yields would have leveled off or declined by 1972.

Risk in Using the New Technology

In a rainfed area such as Puebla it can be argued that the average expected increases in yield and net income from the use of the new technology are not as important to the farmer as is the probability that net income using the Project recommendations may be less than with the traditional practices in some years. It seems reasonable that the major concern of many low-income farmers is to assure an adequate food supply in very unfavorable years; i.e., their first concern is in maximizing the probability of covering family needs in poor years, rather than maximizing average yields and net income.

To the extent that this sort of decision-making occurs, it can be expected that small farmers will accept or reject the new technology in terms of their perception of how it will influence their net income in an unfavorable year. Although the Project did not directly measure farmers' perceptions of the risk involved in adopting the new technology, some appreciation of the importance of such risk can be obtained from information collected during the 6-year period 1967-1972.

As described in Chapter 3, net incomes from the use of several production strategies were calculated from the results obtained in 125 fertilizer rate–plant density experiments conducted during 1967-1972. These net incomes were used to estimate the risks farmers take in using the several technologies. Risk was defined arbitrarily as the standardized probability of obtaining an increase in net income from the use of a given technology equal or inferior in value to: (a) 0.5 ton/ha of maize grain or (b) 0 ton/ha of maize grain.

As shown in Table 3.14 for traditional technology, risk defined as the probability of a net income of 0.5 ton/ha or less, was nearly four times as great in producing system 1.1.1.; three times as great in system 2.1.1; and 32 percent greater in the entire area–as compared with that using recommendations for unlimited capital. When defined as the probability of a net income of 0 ton/ha or less, risks using the traditional practices were nearly three times as great in producing system 1.1.1; twice as great in system 2.1.1; and about 4 per cent less for the entire area–as compared with that of using Project recommendations for unlimited capital.

Comparison of net incomes and risks using Project recommendations for unlimited capital and those for traditional practices suggests several observations about the relative risks involved: (a) for average and favorable years there is a high probability of an attractive income from using either technology; the expected net income is nearly twice as large with the Project recommendations as with traditional practices; (b) for less favorable years, the value of the net income will be equal to or less than 0.5 ton/ha of maize in many instances; the probability of these low incomes is much higher with the traditional than with the recommended technology; (c) for the least favorable years, net incomes less than zero can be expected: the probability of net losses is similar for the two technologies; and (d) net incomes using the traditional technology are sometimes (12 percent of the experiments during 1967-72) larger than the Project recommendations. Based on the available information it appears that farmers, as a whole, would assume less risk by using the Project recommendations than by using the traditional technology. There are instances, nonetheless, where farmers will lower their net incomes by switching from the traditional to the new technology. Hopefully, the frequency of these latter situations can be gradually reduced as agronomic knowledge of the area is improved.

It seems quite likely that the above evaluation of the significance of risk differs from farmers' perception of the risk involved in using the new technology. The results farmers have obtained from using the Project recommendations have been less favorable than those reported in the experiments, which can be attributed to failure to use the recommendations fully, as discussed earlier. The farmers have probably encountered a higher percentage of cases (higher than the 12 percent cited previously) where the Project recommendations have been less profitable than the traditional practices. Also, the experience of the farmers extends over a much longer span of years than the period covered in this study, and almost certainly includes years less favorable than any of those of the 1967-1972 period. It seems reasonable to conclude that a certain percentage of the farmers in the area, perhaps one-fourth, now feel that a change from the traditional to the new technology would mean a reduction in net income from their maize in the less favorable years.

Availability of Credit

As can be calculated from the information in Table 3.10, the average cost involved in using the Project recommendations for limited capital is 19 percent greater than for the traditional technology; the average cost of the recommendations for unlimited capital is 82 percent greater than for the traditional technology. According to the data collected in the area, only about 15 percent of the farmers have sufficient personal funds to purchase the inputs required by the Project recommendations. Thus, in deciding whether to use the new technology, the greater fertilizer cost and the necessity for credit to cover this expense is a major consideration for most farmers.

The discussion of the credit institutions in Chapter 7 suggests that the supply of credit available through the official banks for maize production has been equal to or greater than the demand in recent years. A study of 29 farmers not on credit lists from five communities in the Puebla area in 1973 indicated that there were two main reasons why more farmers did not request credit from one of the official banks: (a) 15 of the farmers (52 percent) feared that they would not be able to pay back the loan–they were particularly concerned about the possibility of an unfavorable year, and about their lack of understanding of the whole process of obtaining credit; and (b) seven of the farmers (24 percent) were repelled by the number of requisites they had to meet to qualify for a loan–they were particularly bothered by having to pay a premium for crop insurance that they felt provided no real protection.

From the standpoint of the farmer, it appears that the lack of satisfactory access to available credit is limiting his adoption of the Project recommendations. Supporting evidence for this conclusion was presented in Chapter 7–the demand for credit from the Impulsora de Puebla, which can be arranged for very simply and without crop insurance, has been far greater than the supply. Hopefully, this obstacle can be overcome, both through favorable change in the credit institutions and by increasing farmers' knowledge of the operation of the banks and the adequacy of the recommendations.

Farmer organizations

Recognizing the farmers' credit needs for the purchase of fertilizers, as well as the difficulties individual farmers have in securing loans from the banks, the Project team began in 1969 to assist small farmers to organize and work together as organized groups. This activity of the Project team has been viewed as an essential part of the operational strategy of an agricultural program where the ratio of small farmers to technical assistance agents is very large. This emphasis on farmer organization has increased the number of farmers in the area who have been able to obtain credit for maize production. The questions can be asked, however: Are the requirements for becoming members of a group too difficult? Would adoption of the Project recommendations increase if such requirements were less restrictive?

Information relating to these questions was collected in 1973 in interviews with 69 farmers belonging to 35 groups distributed throughout the area. Approximately 65 percent of the farmers indicated that the only requirement for becoming a member of their group was that the candidate be an honest, responsible person who fulfilled his obligations. About 20 percent of those interviewed indicated that candidates had to deposit some piece of property with the representative of the group to guarantee that they would pay back the loan at the end of the year. This latter requirement at first appeared restrictive. However, investigation revealed that it was necessary only that the candidate, if considered to be honest and responsible, sign a contract with the group in which he agreed to repay the loan at the end of the year.

Clearly, those farmers who are judged by their neighbors to be dishonest and irresponsible are unlikely to become members of the farmer organizations. Apart from these, however, there was no clear evidence that the requirements for membership in the groups constitute a factor limiting farmer adoption of the maize recommendations.

Other Factors

Characteristics of the farmer, his family, and his land (such as level of education, size of the family, number of members of the family that work, family capital resources, farm size, quality of the land, etc.) probably influence the farmer's decision to adopt or not adopt the Project recommendations. With the information available it was not possible to determine the importance of the first four of these factors on adoption.

The 1970 survey data, however, were used to study the influence of farm size on farmer use of the maize recommendations. The amount of nitrogen used by the 50 percent of the farmers with the largest farms was compared with the amount used by the 50 percent of the farmers with the smallest farms. On the average, the farmers with the larger holdings used 41 percent more nitrogen per hectare than the farmers with the smaller holdings.

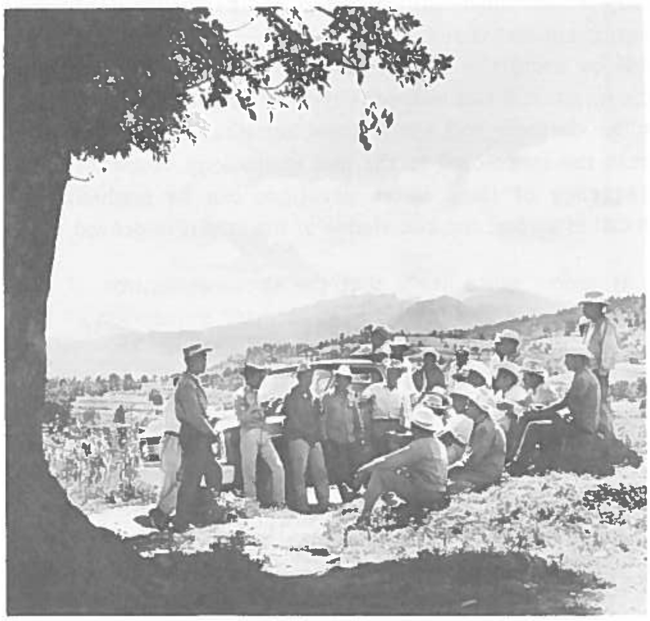
Quality of land almost certainly influences the adoption of new technology. Farmers recognize differences in the potential of lands to produce and are more likely to use expensive technology on land with high-yielding potential. It was not possible to study this factor in Puebla as information on land quality of the sampled individual holdings was not available.

Other factors which often influence the adoption of new technology are the relationships between input costs and product prices, availability of inputs, and the network of roads in the project area.

Obviously, the more favorable the relationship between maize prices and fertilizer costs in Puebla, the more likely that farmers will adopt Project recommendations. It seems unlikely, however, that prices have been an important factor restricting farmer use of the new technology. The relative prices of maize and fertilizers have remained fairly constant during the 1968-1972 period. Approximately 4 kg of maize remained equal in value to 1 kg N; and 3 kg maize to 1 kg P_2O_5. As noted in Chapter 3, net income from the use of fertilizers is quite favorable in most of the producing systems in the area, with this price relationship.

Fertilizers were sold in some 46 towns and villages in the area during the early years of the Project. Since 1971, most fertilizers have been distributed through the official banks and franchised dealers in six major towns. In most instances, however, farmers have been able to purchase the quantities of fertilizers they need. On occasion, however, they have had to wait several weeks for fertilizer deliveries and have not always been able to buy the materials they prefer. Difficulties in purchasing fertilizers have probably had some influence on the adoption of the maize recommendations, because: (a) farmers who were lukewarm about the use of fertilizers, have decided to use less fertilizer in the face of inconveniences in procurement, (b) those who have been unable to purchase fertilizers prior to planting have, at times, reduced their rate of seeding and thus have obtained lower returns from the fertilizers; and (c) those who have received and applied fertilizers later than recommended have sometimes been disappointed with the results.

Difficulties in transporting fertilizers and produce have probably not influenced the rate of adoption of the Project recommendations. As mentioned in Chapter 1, there is an adequate system of roads in the Puebla area.



The organizing of farmers into groups has helped to increase the number of small farmers that have been able to use project recommendations.

10 IMPACT OF INCREASED PRODUCTION ON INCOME, EMPLOYMENT, GENERAL WELFARE

INTRODUCTION

The objectives of the Puebla Project have been stated in terms of production; not because the primary concern was in producing more maize, but because higher yields of maize appeared to be an important first step in increasing net income that, in turn, would provide farmers with new opportunities to improve their general welfare.

Empirical evidence indicates that there is an abundant labor supply in the rural areas of Puebla. Emphasis, therefore, has been on developing and promoting new technologies that can be used effectively with animal-drawn equipment and hand labor, and that will tend to increase the level of employment.

Data from the surveys in 1967 and 1970 are compared in this chapter to show changes in income, employment, and other factors influencing the welfare of the farmer, during the first three years of the Project.[1]

CHANGES IN FAMILY INCOME

The average total family income[2] for all farmers in the Project area was $666.80 in 1967 and $825.52[3] in 1970. The increase in real income over the three year period was 23.8 percent.

The contributions of four components to the total family income, expressed as percentages, are shown in Table 10.1. The percentage of the total family income derived from crop production of all farmers in the area increased from 30.4 percent in 1967 to 35.5 percent in 1970. The percentage of the total income generated from animal production remained almost constant during this period. The relative contribution of off-farm income declined from 40.7 percent in 1967 to 27.7 percent in 1970.

The average family net income from crop production increased from $202.57 in 1967 to $293.06 in 1970, or by 44.7 percent. The available information indicates that this increase in average net income from crop production was due to an increase in average net income per hectare. The gross income per hectare from maize production (grain plus stalks) increased by 44.7 percent from 1967 to 1970, while the gross income from other crops increased by 41.0 percent.[4] The large increase in gross income from other crops may have been due in part to a shift from maize to higher value crops by those farmers who have some irrigation facilities, and by a tendency for farmers who are using the new maize technology to increase their rates of fertilization of other crops.

TABLE 10.1. The percentage contribution of four components to the total farm family income.

Component	1967	1970 All farmers	1970 Farmer on credit lists
Net income from crops*	30.4	35.5	51.8
Net income from animals	28.4	30.0	16.1
Off-farm income	40.7	27.7	27.1
Miscellaneous income**	0.5	6.8	5.0

* The value of the grain and stalks of maize accounted for 60.9% of the gross income from crops of all farmers in 1967 and 61.5% in 1970; it accounted for 79.6% of the gross crop income of farmers on credit lists in 1970.

** This component includes income from the rental of machinery, implements and work animals, sale of irrigation water, gifts, and capital gains.

1. As discussed in Chapter 8, page 78, the segments used in the 1970 survey did not represent a random sampling of the Project area. Thus it is not possible to test hypotheses about changes in population parameters that might have occurred between 1967 - 1970. The information presented in this chapter is intended to indicate the direction of change, rather than the magnitude of change.

2. The following concepts were considered in calculating the total family income: (1) value of crop production, (2) value of the change in inventory of animals, (3) value of animal products, (4) family income from off-farm work, (5) miscellaneous income, (6) costs of crop production, (7) costs of animal production, and (8) costs of hired labor.

3. The average total family income in 1970 was $913.84. This income was deflated, taking 1967 as the base, using the price index of Mexico City (1970=110.7) as reported by "Indicadores Economicos", Gerencia de Investigaciones Economicas. Banco de Mexico, S.A. Vol. I, Dec. 1972. All incomes mentioned in this chapter have been adjusted to 1967 values.

4. Maize accounted for 71.0 percent of the cultivated area in 1970 and 61.5 percent of the total value of crop production.

The 30 percent of the total family income derived from animal production in 1970 was unequally distributed among the farmers in the area. Gross income from milk (94.4 percent of which was sold) accounted for 66.5 percent of the total gross income from animal products and the change in inventory of animals. Forty-two percent of the gross income from milk went to a single family and 81 percent went to four families. Gross income from eggs (11.7 percent of which were sold) accounted for only 2 percent of the total gross income from animal production.

As mentioned in earlier chapters, "farmers on credit lists" refers to the farmers organized in groups who receive credit for purchasing the inputs needed to follow the recommendations of the Puebla Project. The average total family income for this category of farmers was $771.20 in 1970, about 6.6 percent less than the average for all farmers in the area.

Table 10.1 shows that the composition of the income of farmers on credit lists differs from that of all farmers in the area, mainly in that a larger percentage of the income of the credit-listed farmers is derived from crop production with a smaller income percentage from animal production. In 1970, for example, the average family net income from crops was $399.48 for farmers on credit lists compared with $293.06 for all farmers in the area. The average gross income from milk production in 1970 was $53.42 for farmers on credit lists versus $253.00 for all farmers in the area. The value of the milk production of the largest single producer in the credit-list category was $2,308; for the all-farmers category the comparable value was $25,344.

Perhaps of greater significance than the change in the average total family income is the decrease in the percentage of families with very low incomes. Table 10.2 shows the distribution of family incomes among five income ranges in 1967 and 1970. From this information it is seen that the percentage of all families in the lowest income category decreased from 55.8 percent in 1967 to 43.5 percent in 1970. These results show that many families in the income category of $400 or less realized increases in income during the three year period.

The average total family income for all farmers in the Project area increased from $666.80 in 1967 to $825.52 in 1970. Farmers are using this higher income both for home improvements and production investment. Some are beginning small animal production enterprises, such as this hog unit.

TABLE 10.2. Distribution of annual family incomes among five ranges in 1967 and 1970.

Ranges in annual family income	1967 % of all families (N=251)	1970* % of all families (N=239)	1970* % of families of farmers on credit lists (N=213)
400 or less	55.8	43.5	39.9
401 to 600	12.3	20.1	17.4
601 to 1000	16.3	18.0	18.8
1000 to 2000	10.0	11.3	18.8
2000 or more	5.6	7.1	5.1

* Family incomes in 1970 were adjusted to 1967 prices.

CHANGES IN EMPLOYMENT

There is a high level of unemployment and underemployment in most rural areas of Mexico due to the: (a) rapid growth in population, (b) low productivity of the traditional agriculture, and (c) small number of job opportunities outside of agriculture. The Puebla Project has worked to increase the level of employment by developing and promoting a new technology for maize production that requires more labor per hectare and enables the farmers to increase their net income. It is hoped that higher incomes will permit farmers to gradually build up capital reserves that can be used to increase the productive capacity of their resources. If farmers invest this capital in activities that increase the use of labor, such as a shift from maize to alfalfa or vegetable crop production, the effect on employment, catalyzed by the Puebla Project, should be much greater than the initial effect resulting from the use of the new maize technology.[5]

Table 10.3 shows the labor requirements for producing one hectare of maize using the traditional practices and the requirements for the practices recommended by the Puebla Project. The average number of man-days required to produce one hectare of maize is increased from 40.6 man-days to 52.7 man-days, or by 30 percent, when a change is made from the traditional to the new technology. The higher labor requirements of the new technology occur at planting, at the second cultivation, and at harvest.

5. There is no clear indication in the Puebla area that new capital from the use of the improved maize technology will be invested so as to increase employment. On the one hand, there is a tendency to slowly diversify land use in the small areas where irrigation is available. On the other hand, there are cases where farmers have purchased animal-drawn implements, such as cultivators, planters, and fertilizer distributors, that reduce labor requirements. The main justification for increasing the use of laborsaving farming implements is that farm labor becomes scarce at times of peak demand – at planting, time of fertilizing, and at harvest.

TABLE 10.3. Labor requirements for growing one hectare of maize using traditional and recommended practices.

Activity	Traditional planting man-days	Planting using recommendations of the Puebla Project. man-days
Land preparation in fall		
Plowing	3.0	3.0
Smoothing	0.4	0.4
Second land preparation		
Plowing	3.2	3.2
Smoothing	0.4	0.4
Third land preparation		
Plowing	1.8	1.8
Smoothing	0.3	0.3
Planting		
Rowing out	1.7	1.7
Planting	2.6	4.2
Fertilizing	-	1.8
First cultivation		
Cultivating	1.7	1.7
Fertilizing	0.8	-
Uncovering plants	2.1	2.5
Second cultivation		
Cultivating	1.8	1.8
Fertilizing	0.4	2.4
Straightening plants	1.8	1.8
Harvest		
Cutting the stalks	2.0	3.3
Shocking the stalks	1.6	2.2
Shucking the ears	8.6	12.0
Shelling the grain	6.4	8.2
Total	40.6	52.7

These differences in the labor requirements between the traditional and new technology can be used to estimate the change in the average level of employment in maize production per farm family that can be attributed to the adoption of the recommended practices from 1967 to 1972. An assumption can be made that the labor requirements for traditional plantings of maize shown in Table 10.3 represent the average level of employment per hectare in maize production in 1967. It can also be assumed that the new technology was used in 35 percent of the area planted to maize in 1972[6]. The average area that each farmer planted in maize was approximately 2.1 ha in 1972. Multiplying this value by 35 percent gives 0.74 ha, the average area in which farmers used the recommended practices. When this area is multiplied by 12.1 man-days (the increase in labor requirements per hectare in using the new technology) the resultant is 9.0 man-days, or the approximate labor increase per farm family due to use of the recommendations. That is, each farm family on the average increased the number of days spent in growing maize from 85.3 in 1967 to 94.3 in 1972, or by 11 percent.

These increases in employment, although important, are relatively small compared with the level of seasonal unemployment in the Project area. Clearly, it is important to promote other activities in the area that will complement the effect of the improved maize technology in increasing the level of employment during those periods of the year when labor requirements for farming are not high.

OTHER CHANGES THAT INFLUENCE THE GENERAL WELFARE

As noted previously in this report, the Project planners expected that higher family incomes would lead to improvements in the general welfare of the farmers. The following data provide a description of changes in food consumption and improvements in the home between 1967 and 1970.

Family welfare can also be influenced by many other factors, including the availability of public services such as potable water, electricity, schools and health centers; such availability can be affected by action by the farmers on the institutions that provide these services. Information on changes in the availability of these services is presented here with no attempt to assess how such changes were brought about.

According to the 1967 survey, 44% of the farm families lived in houses with only one room besides the kitchen. By 1971, thirteen percent of the farmers had added another room to their houses.

6. As discussed in Chapter 9, the several recommended production practices have been adopted at different rates, and there is no way to quantify precisely the level of adoption of the new technology.

Changes in the Consumption of Several Foods

Table 10.4 shows the frequencies with which farm families consumed ten selected foods in 1967 and 1970. Certain changes in the pattern of consumption are evident. As shown in columns 1 and 2, the frequency with which farm families were eating fish, cheese, chicken, eggs, fruit, vegetables and rice increased between 1967 and 1970. Column 5 shows a decline in the number of families that never ate fish, chicken, eggs, fruit and vegetables.

Frequencies of consumption of maize and beans were not recorded in the surveys, as it was assumed that all farm families ate these foods daily. The total annual consumption of maize per person was estimated to be 223 kilos in 1967 and 253 kilos in 1970. The total annual consumption of beans per person was estimated to be 11 kilos in 1967 and 17 kilos in 1970. Although considerable error is involved in estimating average levels of consumption from survey data, the above figures do suggest that farm families were eating more maize and beans in 1970 than in 1967.

Improvements in the Family Home

Forty-four percent of the farm families in 1967 lived in houses with only one room plus a kitchen; 36 percent lived in houses with earth floors. According to the surveys in 1967 and 1970, the average number of members per family increased from 5.5 to 6.2 during the three-year period. In light of these conditions and the seasonal unemployment in the area, it would be expected that an increase in family income would be reflected immediately in improvements in the farm home.

Seventy of the 239 farmers in the 1970 survey, or 29 percent, reported improvements in their homes. The most frequent improvement, realized by 32 of the farmers, was the addition of a room to the home.

Use of Public Services

Of the 251 farmers interviewed in the 1967 survey, 63 percent had electricity in their homes, 13 percent had potable water, and 6 percent had plumbing. Of the 239 farmers interviewed in the 1970 survey, 77 percent had electricity in their homes, 21 percent had potable water, and 6 percent had plumbing. Eighty-three percent of the farmers who had none of these services indicated that they would cooperate with either work or money to bring these services to the community and to their homes. This finding suggests that the majority of the farmers value these services very highly.

Sixty-seven percent of the farmers interviewed in the 1970 survey stated that their children could study through the sixth grade in their communities, 21 percent stated they could study through secondary, and 2 percent indicated that they could finish high school. The farmers who stated that their children could only finish primary school were almost unanimous in their belief that this amount of education was insufficient to enable their children to find jobs away from the farm. Nevertheless, nearly all the farmers indicated that money spent on the education of their children was a good investment, as it would improve their chances of finding better jobs.

Of the 239 farmers interviewed in the 1970 survey, 12 percent (28) stated there was a medical center of the Ministry of Health and Welfare in their communities, 86 percent indicated there was no medical center in their communities, and 2 percent did not know. Only 11 of the 28 farmers that knew of the existence of a medical center in their communities indicated that they, or some member of their families, had visited the center on at least one occasion. Fifty-nine of the farmers with no medical center in their communities said that they, or some member of their

TABLE 10.4. Frequencies of consumption of 10 selected foods by farm families.

	Percentage of farm families that consume the food al least once every:								Percentage that never eat the food	
	1 to 3 days (1)		4 to 7 days (2)		Month (3)		Year (4)		(5)	
Foods	1967*	1970*	1967	1970	1967	1970	1967	1970	1967	1970
Fish	0.8	0.8	3.2	11.3	8.8	15.9	72.9	66.5	13.9	4.2
Beef or pork	8.4	9.6	43.0	43.9	17.1	28.0	26.7	14.6	3.2	2.9
Milk	29.1	27.6	7.6	7.9	0.4	10.5	20.7	9.6	38.2	43.1
Cheese	1.6	4.6	17.5	23.5	8.8	27.6	36.6	12.1	31.1	30.5
Chicken	0.4	1.7	5.6	14.6	13.1	40.2	59.0	29.7	17.5	12.5
Eggs	29.1	59.4	25.9	32.6	8.0	11.3	25.1	3.3	9.2	2.5
Wheat bread	33.5	38.5	35.4	30.5	4.0	9.6	15.9	6.3	8.4	13.8
Fruit	11.6	30.5	32.7	37.2	9.2	15.5	35.4	10.9	8.0	5.0
Vegetables	14.4	34.3	31.5	38.5	6.8	12.6	30.7	4.2	12.0	9.2
Rice	16.8	30.6	44.2	46.9	11.6	14.2	19.1	2.5	4.4	5.0

* The number of farmers interviewed was 251 in 1967 and 239 in 1970.

families, had on at least one occasion visited a center in another community. That is, 70, or 29 percent, of the 239 farmers had used the services of the medical centers on at least one occasion.

One indicator of the health conditions of the farm families in the area is that 11 percent of the heads-of-families were disabled for health reasons from 1 to 5 days during 1970, 10 percent from 6 to 30 days, and 12 percent from 31 to 90 days.

Changes in Attitudes of Farmers

It is commonly thought that the attitudes of traditional farmers toward agriculture tend to be pessimistic or fatalistic, and that these attitudes should become more optimistic in order to achieve a continuous evolution of a traditional agriculture toward a modern one. It seems reasonable to assume that the attitudes of farmers toward agriculture are the result both of their cultural heritage and their own experiences as farmers. If they are to change these attitudes, one of the means might be to prove to themselves that new ideas or practices offer more advantages than the traditional ones.

The availability of a new maize technology in the Puebla area in 1968 offered farmers the opportunity to compare these new practices with traditional ones. Questions were asked in the 1970 survey to determine the extent to which farmers had found the new technology advantageous. Forty-four percent (104) of the 239 farmers interviewed in 1970 said that they had increased their maize production between 1967 and 1970. Of this 44 percent, 82 farmers, or 79 percent, attributed the increase either directly or indirectly to the use of the recommendations of the Puebla Project.

Of the 213 farmers on the credit lists who were interviewed in the 1970 survey, 154, or 72 percent, said they had increased their maize production during the previous three years. Ninety-three percent of these 154 farmers attributed the increase either directly or indirectly to the recommendations of the Puebla Project.

It is very probable that these increases in maize production have modified the expectations of the farmers with respect to agriculture. Such changes in the expectations of the farmers were estimated by asking the farmers what activity they would engage in were they suddenly to receive an amount of money greater than their total annual income. Of the 251 farmers interviewed in 1967, only 53 percent said that they would continue to farm and would buy more fertilizers. Seventy-three percent of the 239 farmers interviewed in the 1970 survey indicated that they would continue to farm and would improve their production methods. Eighty percent of the 213 farmers on credit lists who were interviewed in the 1970 survey stated that they would continue to farm and would improve their production methods. These results indicate that the number of farmers who feel that it is worth-while to make larger investments in agricultural production increased from 1967 to 1970.

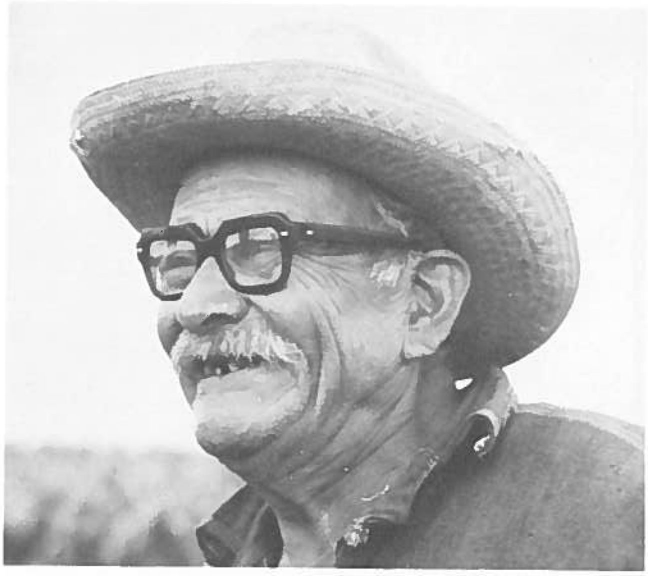
In addition to estimating the change in farmers' expectations with respect to farming, the change in their expectations with respect to progress was also estimated. A nine-level scale was developed in which the first level represented the living conditions of the poorest farmers in the area, with the ninth level representing the farmers with the best standard of living. When interviewed, the farmer was asked to select the level that best represented his present situation and the situation he expected to attain within five years. The results are shown in Table 10.5.

The percentage of farmers who located themselves in the lowest two levels decreased from 28.3 percent in 1967 to 22.2 percent in 1970. A similar reduction is noted in the percentage of farmers that expected to remain in the lowest two levels after a period of five years.

The change in expectations with respect to farming is larger than the change in expectations with respect to progress. This may be due to the fact that farmers, to date, have experienced mainly an increase in net income from crop production, thus, their attitudes toward farming have been most affected.

TABLE 10.5. The percentages of farmers whose living conditions, according to their own evaluations, corresponded to nine levels varying from the poorest (1) to the best (9) in the area.

	1967 (N=251)		1970 (N=239)	
Levels	Present situation	Situation within five years	Present situation	Situation within five years
1 and 2	28.3	13.6	22.2	7.5
3 and 4	33.0	19.6	39.7	21.7
5 and 6	25.9	24.3	25.5	31.0
7, 8 and 9	11.2	34.3	10.9	35.6



Farmers that have increased their production and net income through the use of the new maize technologies, have become more optimistic about the future. This change was reflected in the answers given by farmers when questioned in the 1967 and 1970 surveys.

11 A BENEFIT : COST ANALYSIS OF THE PUEBLA PROJECT

INTRODUCTION

Calculation of the relationships between benefits and costs of the Puebla Project required several initial decisions and assumptions with respect to: (a) the type of benefits to be included, (b) the assignment of values to the resources used and benefits produced, (c) the adjustment of costs and benefits for different years to the values prevailing during a reference year, and (d) the number of years to be considered.

The problem of assigning values to the goods and services used in the Project, and to the resulting benefits, arises from the fact that market prices may not represent accurately the social value of the alternative use of the resources nor the preferences of society for the benefits. For this report, however, it was assumed that, with the eventual exception of farm labor, market values approximate both the alternative costs of the resources employed and the preferences of society for the benefits.

Costs and benefits corresponding to a given year were adjusted to the values prevailing in a reference year for two reasons: (a) the value of money generally increased from year to year due to inflation, and the same monetary benefits received in different years had different real value; and (b) benefits received at a given time could be reinvested, thereby permitting the generation of additional benefits. Thus, the difference in value of a dollar of benefits obtained in different years was determined by the change in monetary prices between these years and by the rate of return that the reinvested benefits could produce.

The cost-benefit analysis presented here covers only the seven year period, 1967-1973, although it is clear that benefits will continue to accrue well beyond 1973.

CLASSIFICATION OF BENEFITS AND COSTS

The most common practice in defining the type of benefits to include in a benefit-cost study is to consider only those quantifiable benefits directly attributable to the project. Although seldom considered because of the difficulty in identifying or quantifying effects, two additional benefits can be included: (a) quantifiable economic effects indirectly induced by the operation of the project; and (b) intangible benefits generated by the project, including changes in attitudes and expectations of the individuals who participate in the project, changes in organization, and gains in knowledge through learning-by-doing in the use of new technology and in arranging for institutional services such as credit.

Costs of a project can be classified as: (a) operational costs, the value of the goods and services used to establish and operate the project; and (b) associated costs, the value of the goods and services that are necessary to perform the activities of the project—maize production, in this case. (Should there be an activity similar to that of the project in an area, then the associated costs charged to a project would be the difference between costs that would have been incurred had the project not existed and costs incurred within the project.)

For agricultural projects, the net direct benefit is the gross value of the project's agricultural production, less the gross value of estimated agricultural production without the project, less the estimated difference in the associated costs incurred with and without the project.

ESTIMATION OF A BENEFIT-COST RATIO FOR SEVEN YEARS OF OPERATION OF THE PUEBLA PROJECT

The benefit-cost ratio was calculated using the following formula:

$$\frac{B}{C} = \frac{\sum_{i=1}^{i=7} \dfrac{(b_i - a_i)}{(1+r)^i (P_i)}}{\sum_{i=1}^{i=7} \dfrac{C_i}{(1+r)^i (P_i)}}$$

where

$i = 1, 2, \ldots, 7$

B = present value of the stream of real benefits of the Project for the seven-year period

C = present value of the stream of real costs of the Project for the seven-year period

b_i = gross benefit attributable to the Project in the i^{th} year

a_i = associated cost attributable to the Project in the i^{th} year

C_i = cost of the Project in the i^{th} year

r = discount rate

P_i = price index for the i^{th} year using 1967 as the base period

The Puebla Project has been oriented primarily toward increasing maize production, and secondarily toward increasing the production of beans, fruits, forages, and vegetable crops. Information was available, however, only on annual changes in maize yields; thus, only benefits derived from maize production are considered here.

Two alternatives were available to estimate the direct benefits accrued from maize production: (a) to consider only increases in production obtained by farmers on credit lists, as direct benefits due to the Project, or (b) to similarly consider the increases in production obtained by all farmers in the area. It was decided to consider only increases in maize production obtained by farmers on credit lists as direct benefits, and to treat increases in production obtained by the rest of the farmers in the area as derived benefits.

Direct Gross Benefits

For the farmers on credit lists, the annual increase in maize yields attributable to the new technology was calculated by taking the difference between the observed average annual yield and the average annual yield assuming no change due to the new technology. These yields have been estimated in Chapter 9 using two alternative procedures. The average yields assuming no change in technology estimated in Table 9.9 were used instead of those estimated in Table 9.10 because they lead to a more conservative estimate of the direct benefits of the Project. These annual increases in maize yields were multiplied by the number of hectares cultivated by farmers on credit lists to obtain the increases in production attributable directly to the Project.

The values of the increases in maize production were calculated using the price guaranteed by the official Mexican purchasing agency, CONASUPO. Over the years, the market price of maize has deviated somewhat from the guaranteed price, depending on amounts harvested; however, $75.20 per ton seems a reasonable approximation to the average price that farmers received for their maize between 1967 and 1972. The price paid by CONASUPO was increased to $96.00 in 1973, and this value was used in estimating benefits for that year. The direct gross benefits are shown in Table 11.1.

Derived Gross Benefits

The derived gross benefits were considered to be the value of the increases in maize production obtained by all farmers in the area not on credit lists. Since there probably would have been a small increase in maize production in the area in the absence of the Puebla Project (as has occurred in parts of Mexico), it is possible that this method of calculating derived benefits overestimates the true values. For the purposes of this analysis, however, it was assumed that the increases in maize production during the 1967-1973 period due to effects exogenous to the Project were insignificant and could be ignored.

As a compensating factor, the derived benefits have been underestimated by considering only the value of the increases in maize production obtained by the farmers not on credit lists. As mentioned earlier, the Project has provided some assistance to farmers in improving their production of beans, fruits, forages, and vegetable crops. Benefits derived from these secondary activities have not been included in the analysis, because no quantitative information was collected on changes in the production of these crops.

TABLE 11.1. The calculation of the direct gross benefits attributable to the Puebla Project, associated costs, direct net benefits, project costs, present value of net benefits and present value of project costs for seven years of operation of the project.

Year	Average maize yield* of farmers on credit lists kg/ha	Estimated average maize yield in the area without the Puebla Project** kg/ha	Average increase in maize yield attributable to the Puebla Project kg/ha	Area benefited directly by the Puebla Project ha	Increase in production attributable directly to the Puebla Project kg	Direct gross benefits + $	Associated costs ++ $	Direct net benefits $	Project costs° $	Present value of net benefits°° 1967 $	Present value of project costs°° 1967 $
1967									52,939		52,939
1968	3894	2091	1803	76	137,028	10,304	3,023	7,281	130,141	6,268	112,031
1969	2765	1715	1050	5838	6,129,900	460,969	213,694	246,275	169,271	182,084	124,645
1970	2670	1777	893	12601	11,252,693	846,202	307,190	539,012	199,380	328,666	121,573
1971	2618	1652	966	14438	13,947,108	1,048,823	286,344	762,479	228,190	393,261	117,693
1972	2920	2011	909	17533	15,937,497	1,198,500	364,056	834,444	219,231	366,986	96,417
1973†	2920	2011	909	20604	18,729,036	1,797,987	430,344	1,367,643	195,253	488,321	69,716
									Total	1,765,586	695,014

* All yields in the table are with 12% moisture for 1967-1971 and 14% moisture for 1972-1973. CONASUPO, the official Mexican marketing agency, used 12% as the maximum moisture content without a discount in price during 1967-1971 and 14% during 1972-1973.

** Information from Column c, Table 9.9. The values for 1967-1971 were adjusted to 12% moisture.

\+ A price of $75.20 per ton was used for the years 1968-1972 and $96.00 per ton for 1973.

++ Assuming zero labor costs.

° Includes an 18% overhead charge.

°° Adjusted for the expected change in value due to income from interest and the change in the price index using 1967 as the reference (See formula, page 95).

† Yields for 1973 were estimated in September, just prior to harvest.

$$\frac{B}{C} = \frac{1,765,586}{695,014} = 2.54$$

TABLE 11.2. The calculation of the derived gross benefits attributable to the Puebla Project, associated costs, derived net benefits, and present value of net benefits for seven years of operation of the project.

Year	Average yield* of all farmers in the area kg/ha	Average yield of farmers in credit lists kg/ha	Average yield of farmers not on credit lists** kg/ha	Change in yield of farmers not on credit lists (%compared to 1968)	Change in yield attributable to climate (%compared to 1968)	Change in yield attributable to the Puebla Project (%compared to 1968)	Increase in yield attributable to the Puebla Proj. kg/ha	Area of maize farmers not on credit lists ha	Increase in production attributable indirectly to the Puebla Project kg	Derived gross benefits + $	Associated costs ++ $	Derived net benefits $	Present value of net benefits° 1967++
1967	1300		1300	-	-	-	-	80,000	0	0	0	0	0
1968	2091	3894	2089	base	base	-	-	79,924	0	0	0	0	0
1969	1790	2765	1713	−18.0	−18.0	0	0	74,162	0	0	0	0	0
1970	1917	2670	1776	−15.0	−15.0	0	0	67,399	0	0	0	0	0
1971	1883	2618	1721	−17.6	−21.0	+ 3.4	71	65,562	4,654,902	350,049	321,516	28,533	14,716
1972	2499	2920	2381	+11.3	− 6.0	+17.3	370	62,467	23,112,790	1,738,082	522,724	1,215,358	534,510
1973°°	2499	2920	2353	+ 9.2	− 6.0	+15.2	325	59,396	19,303,700	1,853,155	497,026	1,356,129	484,210
												Total	1,033,436

* All yields in the table are with 12% moisture for 1967-1971 and 14% moisture for 1972-1973. (See footnote, Table 11.1)

** The average yield of farmers not on credit lists was calculated using the following relationship:

$$\text{Average yield of all farmers} = \left(\frac{\text{hectares of farmers on credit lists}}{80{,}000}\right)(\text{average yield of farmers on credit lists}) + \left(\frac{80{,}000\text{-hectares of farmers on credit lists}}{80{,}000}\right)(\text{average yield of farmers not on credit lists}).$$

\+ A price of $75.20 per ton was used for the years 1968-1972 and $ 96.00 per ton for 1973.

++ Assuming zero labor costs.

° See footnote, Table 11.1.

°° Yields for 1973 were estimated in September, just prior to harvest.

Benefit: cost ratio including derived benefits $\frac{B}{C} = \frac{1{,}765{,}586 + 1{,}033{,}436}{695{,}014} = 4.03.$

Table 11.2, shows that the first step in estimating the derived gross benefits was to calculate the average yields of farmers not on credit lists. The following relationship was used for this calculation:

Average yield of all farmers =

$$\left(\frac{\text{Hectares of farmers on credit lists}}{80{,}000}\right)\left(\text{Average yield of farmers on credit lists}\right) + \left(\frac{80{,}000 - \text{hectares of farmers on credit lists}}{80{,}000}\right)\left(\text{Average yield of farmers not on credit lists}\right)$$

It was assumed that the total harvested area of maize in the Project area was 80,000 ha.

The average yields of farmers not on credit lists, calculated according to the above relationship, are shown in Table 11.2. The differences between the average yields of farmers not on credit lists in 1968 and such yields in the following years are shown as percentages in Table 11.2. These values estimate the changes in yield due to climate and the use of the new technology. These values, less the changes in yield due to climate (Table 9.9, column b), represent the changes in yield attributable to the Project, expressed as percentages.[1] These percentages were multiplied by the average yield of farmers not on credit lists in 1968 to obtain the increases in kg/ha attributable to the Project. Increases in yield were multiplied by the number of hectares of maize corresponding to farmers not on credit lists to obtain the annual increases in production. Increases in production, expressed as tons, were multiplied by the price of maize to obtain the derived gross benefits.

1. The decrease in nitrogen prices by about 14 percent at the national level in 1971 may have contributed to an increase in fertilizer use, and, in turn, in maize yields. The effective decrease in nitrogen prices at the local level was less than 14 percent, due to shortages of fertilizer at periods of peak demand and, consequently, increases in prices by local distributors.

Associated Costs

The associated costs are the costs of fertilizers, transportation, interest, crop insurance, and labor in excess of those incurred by farmers using the traditional technology. It was recognized that the use of the recommended technology requires a more intensive use of farm implements and work animals than the traditional technology, but these increases were considered negligible. Labor requirements calculated in Table 10.3 show that the recommended technology requires some 12.1 man-days per hectare more than the traditional technology. Several alternative assumptions can be made to calculate the associated cost of this increased labor requirement.

Alternative 1 assumes that there is excess rural labor in the area. In this case, there is no associated cost to increased labor requirements.

Alternative 2 assumes that there is seasonal unemployment in the area, but that labor is fully employed at harvest time in cutting and shocking the stalks and shucking the ears. This assumption is consistent with the remark (footnote 5, Chapter 10) that labor scarcities occur at specific times of the year. In this case, hired labor must be found for these activities that imply 5.3 man-days per hectare more than with the traditional technology. Following Cano and Winkelmann[2], the daily wage of hired labor can be set at $1.28.

In Alternative 3, an opportunity cost is charged for family labor so that all 12.1 additional man-days per hectare are accounted for in the associated costs. Again following Cano and Winkelmann, a reservation price can be assumed for family labor at half the wage of hired labor.

2. J. Cano and D. Winkelmann, "Plan Puebla: Análisis de Beneficios y Costos," *El Trimestre Económico,* Vol. XXXIX (4). No. 156, pp. 783-796, 1972.

Alternative 4, which is introduced essentially to obtain the extreme lowest value of the benefit-cost ratio, consists of imputing all 12.1 additional man-days of labor requirements to the associated costs, at the full opportunity cost of hired labor. (By using 12.1 days per hectare as the additional labor requirement of farmers employing the recommended technology, the true increases in labor costs have probably been overestimated. Many farmers on credit lists did not use project recommendations fully and obtained increases in yield less than those used in making the calculations in Table 10.3. Consequently, their additional labor requirements were less than 12.1 days per hectare.)

Other inputs (insecticides, herbicides, improved seeds, etc.) are seldom used; thus, failure to include them in the estimation of associated costs should not affect the global value significantly.

The calculation of the costs associated with the direct benefits varied somewhat over the 1968-1973 period. The fertilizer costs per hectare, using the Project recommendations, were as follows for the years 1968-1973:

Year	Fertilizer Costs ($/ha)
1968	62.88
1969	57.92
1970	45.41
1971	40.42
1972	40.87
1973	41.38

These fertilizer costs include charges for transportation and interest. The value for 1968 is an average cost of fertilizer for the high-yield plots conducted that year.[3] The 1969 figure was calculated from data obtained from the fertilizer distributor, Agrónomos Unidos, which distributed fertilizer for 2,719 ha of high-yield plantings.[4] The values for 1970-1973 were calculated from data provided by the fertilizer distributor, Impulsora de Puebla, on its fertilizer sales to farmers on credit lists.

There was no expenditure for crop insurance in 1968. For 1969-1973, the calculation of the cost of crop insurance was based on the average premium of $6.57/ha paid by farmers in the five Project zones. It was assumed that the area covered by crop insurance corresponding to farmers on the credit lists represented 50 percent of the total holdings receiving credit from the official banks. For these farmers on the credit lists, the estimated number of insured hectares was: 1,560; 3,969; 5,528; 8,009; and 8,186 ha in 1969, 1970, 1971, 1972, and 1973, respectively.[5]

3. Jairo Cano and Delbert T. Myren, "Benefit-Cost Analysis of the Puebla Project," *Strategies for Increasing Agricultural Production on Small Holdings*, CIMMYT, México, D.F..

4. *Ibid.*

5. According to the data in Table 7.2, the total received by farmers in the Puebla area as indemnization in 1969-1971 exceeded total premiums paid to the insurance agency. This suggests that perhaps no charge should have been made for crop insurance.

It was estimated that the cost of fertilizer would have been $23.10/ha if applied according to traditional practices. This estimate included a $20.88 fertilizer cost (320 kg/ha of 10-8-4 at $65.28/ton, including transportation) plus $2.22 in interest. The associated costs used in the calculation of the direct net benefits in Table 11.1 were obtained by subtracting the estimated fertilizer cost using the traditional practices from the fertilizer cost using the Project recommendations.

The average fertilizer costs (including interest) for all farmers in the area and for farmers on credit lists were estimated from data collected in surveys at harvest time in 1971-1972. Estimates of the average fertilizer cost for those farmers not on credit lists were made using the following relationship:

$$\text{Average fertilizer cost of all farmers} = \left(\begin{array}{c}\text{Average fertilizer cost of}\\ \text{farmers on credit lists}\end{array}\right)\left(\frac{\text{Hectares of farmers on credit lists}}{80{,}000}\right) + \left(\begin{array}{c}\text{Average fertilizer cost of}\\ \text{farmers not on credit lists}\end{array}\right)\left(\frac{80{,}000 - \text{hectares of farmers on credit lists}}{80{,}000}\right)$$

These average per hectare fertilizer costs (including a 6.21-percent transportation charge) for farmers not on credit lists were $28.01 in 1971, $31.47 in 1972, and $24.69 in 1973. These average costs, less the $23.10 fertilizer cost using traditional practices, gave the associated costs used in calculating the derived net benefits in Table 11.2.

Project Costs

Calculations of the annual costs of the Project took into consideration: (a) the costs of vehicles, equipment, and other durable items, were charged to the year in which they were purchased, even though they continued to be used for several years, even beyond 1973; (b) an estimation of charges for the rental of offices and work areas, which were made available at no cost; (c) an estimation of charges for services and materials provided by the Graduate College at Chapingo at no cost; and (d) an estimation of the cost of consulting services to the Puebla Project team from specialists in CIMMYT, the Graduate College at Chapingo, and USAID.

Table 11.3 shows the annual costs of operating the Puebla Project, listed by program. Information on individual program costs provides an indication of the relative emphasis placed on the several components of the Project. Program expenses included: costs of salaries, perquisites, travel expenses, equipment, materials, operation and maintenance of vehicles, and miscellaneous materials and services.

An estimation of the costs of the consulting services provided for the five programs is shown in Table 11.4. The total cost used in the calculation of the benefit-cost ratio was the sum of the operating expenses in Table 11.3 and the consulting services in Table 11.4. In addition, the total

TABLE 11.3. Annual costs of the operation of the Puebla Project and each of its five programs*.

Year	Agronomic research	Genetic improvement	Coordination	Technical assistance	Evaluation	Total
1967	18,294	8,826	8,201	–	–	35,321
1968	25,512	24,918	11,964	18,337	19,315	100,046
1969	28,945	29,079	11,144	46,891	15,401	131,460
1970	38,167	37,852	18,036	51,666	10,851	156,572
1971	40,049	33,209	17,930	58,874	29,880	179,942
1972	45,204	22,935	19,349	64,221	18,648	170,357
1973	45,339	7,973	21,351	59,070	17,614	151,347
Total	241,510	164,792	107,975	299,059	111,709	925,045

* Including goods and services not paid by CIMMYT.

cost of operating expenses and consulting services was increased by 18 percent to cover overhead administrative expenses.[6]

Adjustment of Costs and Benefits

The general index of wholesale prices for Mexico City was used to deflate the nominal costs and benefits, taking 1967 as a base period.[7] (See Table A.2 in the Appendix.) This adjustment was made because as average prices of other goods increase while the price of maize remains constant–the exchange value of the farmer's maize decreases, even though he continues to produce the same amount and continues to receive the same nominal value. The price index serves to indicate how much the exchange value of maize decreases in relation to other goods under these circumstances.

To compare costs and benefits corresponding to different years, it is necessary to take into account the added benefits that may be derived from reinvesting capital. The costs and benefits in this analysis were adjusted for added benefits from reinvestment, using a discount rate of 14 percent. The present value of the net benefits and project costs were calculated using the formula on page 95 and are shown in Tables 11.1 and 11.2.

Benefit-Cost Ratios

The present value of net benefits and project costs, calculated in Table 11.1 under the assumption of excess labor, were summed for the seven years, 1967-1973. The present value of the stream of net benefits was divided by the present value of the stream of project costs to obtain a benefit-cost ratio of 2.54 for the Project when only direct benefits are taken into account. Under alternative assumptions (Table 11.5), the benefit-cost ratios were: Alternative 2, 2.20; Alternative 3, 2.15; and Alternative 4, 1.77. The ratio of 2.20, corresponding to seasonal unemployment,

6. The normal overhead charge made by CIMMYT is 18 percent.

7. Indicadores Económicos, Gerencia de Investigaciones Económicas, Banco de México, S.A., Vol. 1, No. 6 (May 1973).

TABLE 11.4. Estimation of the costs of the consulting services provided for the five programs of the Puebla Project.

Year	Agronomic research	Genetic improvement	Coordination	Technical assistance	Evaluation	Total
1967	6,245	1,299	- -	599	1,399	9,542
1968	5,601	749	- -	1,169	2,728	10,247
1969	9,293	- -	- -	809	1,888	11,990
1970	8,172	- -	1,165	1,490	1,567	12,394
1971	4,909	- -	6,028	1,664	839	13,440
1972	6,515	- -	7,815	1,101	- -	15,431
1973	6,838	- -	6,715	569	- -	14,122
Total	47,573	2,048	21,723	7,401	8,421	87,166

TABLE 11.5. Benefit-cost ratios for the Puebla Project under alternative labor cost assumption.

Alternative	Direct benefits only	Direct and derived benefits
1	2.54	4.03
2	2.20	3.48
3	2.15	3.37
4	1.77	2.70

Alternative 1: Excess rural labor in the project area. Labor has a zero opportunity cost.

Alternative 2: Seasonal unemployment except at harvest. Project recommendations require 5.3 man-days per hectare above traditional technology at harvest. Daily wage of hired labor is $1.28.

Alternative 3: No seasonal unemployment. Family labor can provide the 12.1 man-days per hectare required by recommended technology above traditional practices. The opportunity cost of family labor is half that of hired labor or 64 cents per day.

Alternative 4: No seasonal unemployment. The 12.1 man-days per hectare of additional labor need be covered by hired labor at $1.28 per day.

seems to describe best the conditions of the area.

The present values of derived net benefits in Table 11.2 were summed over years and added to the present value of the stream of direct net benefits from Table 11.1, assuming excess labor. The benefit-cost ratio thus obtained for the Puebla Project was 4.03, taking into account both direct and derived benefits. The benefit-cost ratios under alternative assumptions were: Alternative 2, 3.48; Alternative 3, 3.37; and Alternative 4, 2.70. Again, Alternative 2, with a benefit-cost ratio of 3.48, seems to be the most plausible. Table 11.5 summarizes the values obtained.

According to the ratios obtained, investments in goods and services in the Puebla Project during 1967-1973 generated benefits with a value ranging from 2.70 to 4.03 times greater than that of the cost. The farmers now also know how to arrange for credit and how to use the new technology in future years. It can be expected, therefore, that benefits due to the Puebla Project will continue to accrue in years to come: thereby giving a benefit-cost ratio well above 4.0 for direct and derived benefits.

Intangible Benefits

The Project team contributed to important changes in the area in addition to increases in maize production and net income.

An important intangible benefit derived from the Puebla Project is the progress that has been made in assisting farmers to organize in groups and resolve problems in a collective manner. Many farmers in the area are now aware of the advantages in working together in arranging for credit, transporting fertilizers, and petitioning governmental officials for changes in the operational procedures of service agencies.

The technical assistance program of the Project has provided the farmers with a better understanding of the agricultural service institutions. In 1967, for example, most of the farmers in the Puebla area did not know how to arrange for credit from the official banks. Today, however, many farmers understand the procedures for requesting short-term credits for fertilizers, etc.; some also know how to apply for long-term credit to purchase equipment, animals, etc.

Over the long run, perhaps the most important intangible benefit attributable to the Puebla Project will be the favorable change that has occurred in the farmer's attitude toward modern technology and agriculture in general. Successful experience in the use of the new maize technology has given the farmers confidence that improved technology can be useful to them in other farming enterprises, and many have begun to seek new technical information about other activities, such as irrigation, improvement of fruit trees, and vegetable crop production.

Many subsistence farmers have received another intangible benefit in the form of greater certainty (because of the higher yields) that their family will have sufficient maize for the entire year. This represents an important contribution to the general welfare of the subsistence farm family, quite apart from the economic value of the increase in production.

Additionally, as a result of the action of the Puebla Project, problems in the operation of the credit banks and crop insurance company have been identified and studied. Operational procedures of these institutions are being changed so that greater use of these services can be made by the farmers in future years.

12 TRAINING OF STAFF FOR REGIONAL PRODUCTION PROGRAMS

INTRODUCTION

In 1970, the Puebla Project initiated a training program to prepare professional staff for the operation of regional production programs to assist subsistence-level farmers in areas having: (a) physical environments that would permit substantial increases in crop yields, and (b) political environments that were favorable toward increasing crop production.

During the process of developing the training program, specific training activities were discussed and general guidelines were adopted for these programs. The basic premises were that (a) joint action of professionals from several disciplines (agronomy, communications, economics, organization, etc.) would be necessary in the problem-solving process–the training program was designed to provide a philosophy for trainees in which the overall goals of increasing production and net income of the farmers would transcend disciplinary goals, with trainees working together as a team in achieving these overall goals; (b) since the professional staffs trained in Puebla would have responsibility for organizing and operating production programs in their countries, it was important that the trainees develop abilities for effective program planning, as well as in methodological skills; and (c) since staff trained in Puebla were expected to participate in national programs as trainers, the selection of people for training in Puebla, as well as the training program itself, should be directed toward the preparation of professionals with the capacity both to organize and operate production programs and to train other nationals for similar activities. The training role of the Puebla Project was viewed as that of preparing one or two teams of professionals for each interested country, with additional training to be the parent country's responsibility.

PRACTICAL TRAINING

The experiences in the Puebla Project initially indicated that professionals should be selected and trained for five distinct activities: soil improvement, plant breeding, technical assistance to farmers, evaluation, and coordination. Thus, at first, the Project adopted the idea of selecting five technicians, one in each of the five disciplines, and training them together as a team. Each of the trainees spent two-thirds of his time learning the specific skills of his discipline; the remainder of his time was devoted to learning about the activities of the other four members of the team. As experience was gained in training, it became apparent that the practical preparation needed by soils specialists and plant breeders was similar and that needed by technical assistance agents and coordinators was also similar. Therefore, the distinct areas in which practical training was given were reduced to: (a) agronomic research, (b) technical assistance and coordination, and (c) evaluation.

It was recognized that countries interested in initiating regional production programs would have an immediate need for trained teams of professionals for operating these programs. In addition, it was expected that, within a relatively short time, such nations would need more highly trained scientists who could provide competent leadership in the planning and operation of regional programs that would be oriented to their own national needs. These teams of professionals with more complete scietific preparation would also form the basic staff for implementing the national training programs. Considering these two needs, it was decided that the training of staff for regional production programs should be given at two levels.

The first level of training has been given by the Puebla Project team in the Project area. The primary objective of this training is to prepare technicians to work together as a team in all activities. Greater emphasis has been placed on preparing the trainees in the skills needed in their particular programs, than in teaching them the theoretical bases of the methodology. This practical training has required 6 to 8 months of the trainee's time.

Within the practical training, the trainees were expected to reach selected levels of proficiency. For example, specialists in agronomic research were expected to become proficient in: (a) knowledge of soil charactistics such as physiographic position, nature of the soil horizons, and previous management practices, with the ability to locate sites for an experiment, and to arrange with the owner of the farm for the experiment at that location; (b) defining the materials necessary for the experiments (fertilizers, herbicides, insecticides, cord, stakes, chains, etc.), calculating the amounts of materials needed, and preparing the fertilizers, seed, herbicides, etc. for each plot, replication, or experiment; and (c) staking out the experiment, collecting soil samples for analysis, applying the correct fertilizer treatments to the individual plots, plus the plantings, application of herbicides, and other operations involved in the installation of the experiment.

The practical training in agronomic research included training in these activities and many others that are basic procedures in the process of collecting existing information and generating new information to define the production technology recommended for a given area.

Trainees have learned the practical skills needed in their specialties by working directly with the approrpriate members of the Puebla Project team. In addition, they have learned selected basic skills by working with the other members of the Puebla team. While in Puebla the trainees also have participated in other activities with group interaction and discussion. They have attended weekly meetings of the Puebla Project team to discuss problems affecting the operation of the Project and have participated as a group in activities such as the installation of demonstration plots, field days, etc.

COMBINED THEORETICAL AND APPLIED TRAINING

A second level of training has covered both scientific preparation in a discipline and practical experience in the use of methodological skills. This training involves an academic program leading to a M.S. degree at the Graduate College at Chapingo, with a thesis problem investigated in the Puebla area. These graduate programs have been worked out in coordination with professors at the Graduate College. In general, this second level of training has covered a period of about two years, with the first year devoted entirely to course work at the College and the second year to practical training in Puebla (including thesis research).

The Puebla Project team has felt that the professionals who receive both levels of training should continue their academic preparation after work experience in a regional production program for one or more years. Thus, it is expected that countries promoting regional production programs could rapidly develop a nucleus of highly trained, well-equipped professionals.

Table 12.1 shows the numbers of professionals who have received training in Puebla at the two levels. These technicians are now participating in the operation of 10 regional production programs in four countries.

TABLE 12.1. The numbers of professionals who have received training in the Puebla Project.

Country	Level of training*	Year training was initiated					Total
		1967-1969	1970	1971	1972	1973	
Colombia	I	0	3	3	3	0	9
	II	0	5	0	2	0	7
Subtotal							16
Ecuador	I	0	0	2	0	0	2
	II	0	0	0	0	0	0
Subtotal							2
Honduras	I	0	0	0	0	1	1
	II	1	0	0	0	0	1
Subtotal							2
Mexico	I	9	5	7	2	5	28
	II	8	5	0	0	0	13
Subtotal							41
Peru	I	0	0	4	0	0	4
	II	1	0	0	0	0	1
Subtotal							5
TOTAL							66

* The numerals I and II refer to the first (practical) and second (theoretical and applied) levels of training, respectively.

13 PROMOTION OF REGIONAL PRODUCTION PROGRAMS IN OTHER AREAS

INTRODUCTION

From the beginning of the Project, the staff has assumed a responsibility for communicating the Project's progress and experience to agricultural and political leaders in Mexico and other countries. For those countries that might wish to launch similar projects, the Puebla Project planners have felt that the Project should be prepared to assist by training of staff and provision of technical assistance.

By mid-1969 there was agreement among the staff of the Puebla Project that its strategies were proving to be highly effective. This assurance grew out of several developments in the Project: (a) research findings in 1967 and 1968 indicated that most farmers in the area could double maize yields and realize comparable increases in net income; (b) the average yield obtained by 103 farmers who used the recommended practices on a part of their land in 1968 was 3.98 tons/ha of grain, about double the average for the area; (c) as a result of promotional activities during the fall and winter of 1968-1969, 2,561 farmers organized in credit groups and agreed to use Project recommendations on 5,838 ha of maize; and (d) despite an exceptionally dry spring in 1969, by midsummer it was evident that acceptable maize yields and returns on investments in fertilizers would be obtained by farmers using the recommendations. Thus, plans were made to offer these encouraging findings to other parts of Mexico and the world where they might prove useful.

This information was disseminated through various media: (a) exchanges of ideas and experiences with the hundreds of people visiting the Puebla Project each year. These visits also provided opportunities for the staff to encourage more concern for developing effective agricultural programs in areas of small, subsistence farmers; (b) a report published in late 1969 describing the Project and its operational strategies and accomplishments in 1967, 1968, and early 1969. In the year following publication, over 4,000 copies each in English and Spanish were distributed to all parts of the world; and (c) two international conferences held in the city of Puebla in August 1970, to discuss strategies for increasing agricultural production on small holdings. The first conference, with discussions in Spanish, was attended by more than 120 agricultural technicians from Mexico and 14 other Latin American countries. Participants from 15 international development organizations attended the second conference, with discussions in English. A report on the two conferences was published in late 1970, and over 4,000 copies each in both English and Spanish were distributed during 1971.

In mid-1969, a more formal plan was drafted, suggesting use of the Puebla staff and experience for promoting similar regional agricultural programs in other areas of Latin America. At that time, CIMMYT was exploring ways to intensify research on high-quality maize varieties, and the United Nations Development Program (UNDP) was contemplating provisions for financial support of global research programs. The interaction among these three interests culminated in a proposal by CIMMYT, and its approval by UNDP to establish an international program to: (a) conduct research and breeding necessary to provide a range of maize populations and varieties that would be high in nutritive value, have improved yield and agronomic characteristics, and have grain types acceptable for a wide range of local conditions; and (b) assist government agencies in Central and South America in developing regional maize production programs to ensure that maize-consuming subsistence farmers and their families would benefit from the discovery of "high lysine" maize. CIMMYT began operations under this UNDP Global Project Number 1 in March 1970.

The Director of CIMMYT, accompanied by Puebla staff, visited Colombia, Peru, Ecuador, and Bolivia during the first half of 1970 to inform political and agricultural leaders of the Puebla experience, and of the opportunity provided by the UNDP Project for CIMMYT to cooperate in developing similar programs in maize-producing areas of their countries. At the invitation of agricultural leaders in Argentina, Venezuela, and Honduras, similar visits were made to those countries during 1971. The Puebla staff also met with representatives of Mexican institutions to report on the experiences in Puebla and to indicate staff interest in assisting with other programs in Mexico.

Several regional production programs, influenced in some degree by the Puebla experience, have been initiated as a result of these activities. The Puebla staff has been involved both in training technicians and in providing technical assistance. These programs and activities are briefly described in the following sections.

East Antioquía Project, Colombia

Organized in late 1970, this project was an activity of the Colombian Agricultural Institute (ICA), a national organization with responsibility for agricultural research and extension. It is located in the eastern part of the department (state) of Antioquía. The project area consists of 22 *municipios* with a total cultivated area of 172,800 ha.

There are approximately 35,600 farms in the region with an average size of 4.8 ha. Activities have been concentrated initially in six *municipios* near Medellin with a cultivated area of 52,000 ha.

The soils in the area have formed from volcanic ash and belong to the Andosol category. The average annual precipitation varies from 1,500-2,100 mm and falls mainly in the period from April to November. Elevations above sea level vary from 2,000-2,400 m.

Due to high rainfall, high water-holding capacity of the soils, and temperate climate, year-round crop production is possible with a wide selection of crops. Thus, intensive cropping systems are used and the land generally produces two or three harvests per year. More than 20 different cropping systems have been observed in the area. The major crops are maize, beans, and potatoes.

Technical assistance was provided to 4,801 families with 8,212 ha in 1972.

Five similar regional projects were initiated in Colombia during 1971-1972. These projects cover a wide range of both agricultural and social activities and have been designated Rural Development Projects. Project plans call for assistance to approximately 103,000 families. The Extension Service in ICA was reorganized in early 1973 as the Division of Rural Development. Fourteen additional Rural Development Projects have been approved and are presently being organized and staffed.

Cajamarca—La Libertad Project, Peru

This project was organized in early 1971, as a joint undertaking of the Agricultural Research Division of the Ministry of Agriculture, the Cooperative Maize Research Program of the Agrarian University, and the Agro-Industrial Research Institute. Field activities were initiated in September 1971.

The Project area comprises the major part of the high mountainous region of the departments of Cajamarca and La Libertad in northern Peru. The major crops are maize, wheat, barley, and potatoes. Approximately 96,000 ha of maize and wheat are grown in the area annually. The average area of cultivated land per farm is 1.4 ha.

This area is very mountainous and has a very poor road system. Initially, therefore, activities were concentrated in a region about 10 km wide extending from 15 km north of Cajamarca to 15 km south of Cajabamba. About 9,500 ha of maize and 7,500 ha of wheat are grown in this region annually.

The climate of the region varies from sub-tropical in the Condebamba Valley to temperate in the higher valleys and mountain slopes. Elevations vary from 2,000-3,500 m above sea level. Average annual rainfall varies from 650-750 mm. All of the wheat is rainfed and about one-half of the maize receives one or more irrigations.

During the past two cropping seasons, applied research on maize, wheat, and barley was conducted to develop reliable packages of production practices for the farmers in the area. There were 183 field trials in 1971-1972, and 100 field trials in 1972-1973.

The Basic Grains Program, Honduras

The Central Bank of Honduras and the National Development Bank sponsor this program, which is conducted in collaboration with the Rural Development Institute, the Department of Agriculture, and the Panamerican Agricultural School. It was organized in late 1970 and began field operations in early 1971.

The Project area consists of four *municipios* in the Francisco Morazan department. There are approximately 15,000 ha of cultivated land, with 50 percent planted in maize and 32 percent in beans. There are around 3,200 farms with an average size of 4.6 ha and total population of the area is about 40,000.

The cultivated area is concentrated in the valleys of Talanga and Siria, with soils varying from level to rolling and from poorly drained planosolic types to well-drained alluvial soils. The climate is tropical with absolute minimum temperatures of about 9° C. The average annual rainfall is around 1,100 mm, falling mainly from May through October. The cultivated land lies at elevations from 500-700 m above sea level.

The Basic Grains Program expanded its activities in early 1973 to include a second project in the department of El Paraiso. A research program was conducted that year, consisting of about 100 trials on farmers' fields to study varietal performance and production practices for maize, beans, and maize-bean associations.

Maize Program, State of Mexico, Mexico

This program was organized in early 1971 by the Government of the State of Mexico and is operated by a state institution known as DAGEM (organization for the development of crop and livestock production). This institution includes the directors of 13 agencies involved in government, credit, crop insurance, marketing, and organizing of farmers. DAGEM is operated by an Executive Commission and the coordinator of the Maize Program reports directly to this Commission.

The project area comprises the major part of the improtant maize producing regions in the state. It consists of three well-defined zones: Valley of Toluca, covering 34 *municipios;* Valley of Mexico, with 32 *municipios;* and the Southwestern Zone, with six *municipios.* About 430,000 ha of maize are harvested annually in these 72 *municipios.* There are approximately 240,000 farms with an average cultivated area of 2.2 ha/farm.

The soils used for growing maize in the Valleys of Toluca and Mexico were formed from volcanic materials and lie at elevations between 2,240 and 2,800 m above sea level. The cultivated area of the Southwestern Zone lies between 400 and 1,800 m above sea level. The average annual rainfall varies from 500 mm at the northern limits of the region to 1,100 mm at the southern tip of the Valley of Toluca. Frost damaging to maize may occur in the valleys of Toluca and Mexico in all months except June, July, and August.

The Project area is divided into five zones with a Regional Coordinator in charge of each zone. Several "farmer programs" are coordinated by each Regional Coordinator. Each farmer program is headed by an outstanding farmer of the area who promotes the organization of groups of farmers. Each group of farmers then elects a leader who is responsible for maintaining communications between the group and the head of the farmer program. Within this overall organization, a small team of agronomists can provide technical assistance to a large number of farmers.

The Maize Program reported 32 farmer programs functioning in 1972, with a total of 1,277 groups and 19,160 farmers. These farmers used the recommended production practices on 63,568 ha of maize, with an estimated average yield of 3.5 ton/ha. (The estimated average maize yield for the total area was 1.9 ton/ha.)

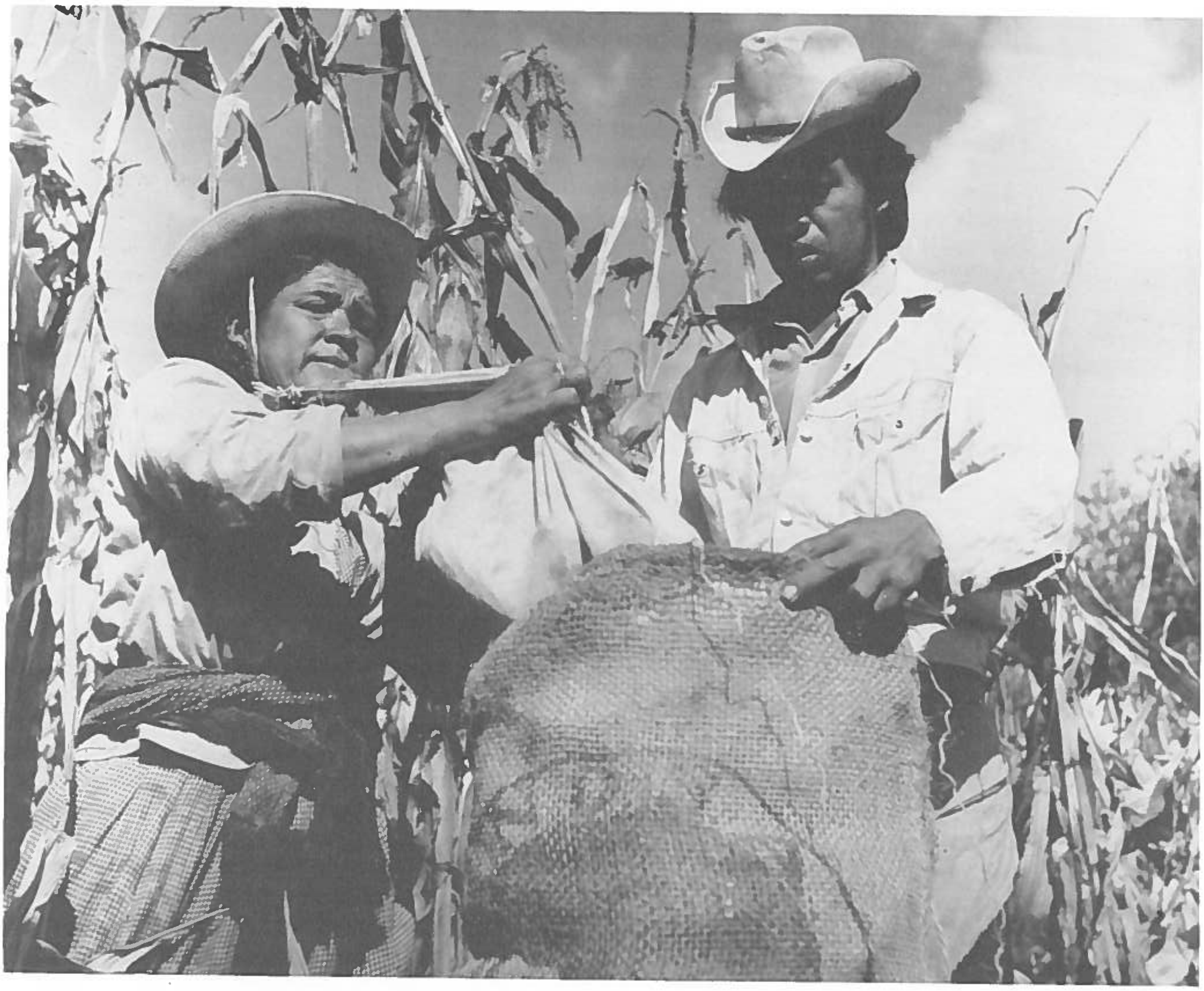
Beginning in 1970, the field staff and advisors of the Puebla Project assisted in the development of similar programs in Colombia, Perú, Honduras, and in the States of Mexico and Tlaxcala, Mexico. Here one of the farmers participating in the Maize Program of the State of Mexico is shown with his wife harvesting their maize.

Tlaxcala Project, Mexico

Organized in early 1971, this project is a cooperative undertaking of the Mexican Ministry of Agriculture and the Government of the State of Tlaxcala. The Project area comprises 18 *municipios* in the southern part of the state. The total cultivated area is 46,000 ha, with nearly 90 percent planted in maize each year. About 40,000 farm families live in the area.

The soils, formed mainly from volcanic ash, are level in the central part of the area, and are gently to moderately rolling on the slopes of La Malinche volcano. The average annual precipitation is 700-800 mm. Most of the cultivated area lies between 2,200 and 2,400 m above sea level.

In 1972, the Project reported that technical assistance was provided to 972 farmers who used the recommended production practices on 2,300 ha of maize. About three-fourths of these farmers were organized in groups (82 groups in 37 communities). The average maize yield of farmers using the recommendations was estimated at 2.4 ton/ha.



14 THE PUEBLA APPROACH : A SYNTHESIS

INTRODUCTION

This chapter briefly describes the Puebla approach for rapidly increasing crop production on small rainfed farms, as it evolved from 1967 to 1973. No attempt has been made in Puebla to test a series of alternative ways for achieving Project goals. Rather, an initial approach was defined in terms of existing knowledge and modifications were made over the years as new information became available.

ESSENTIAL ELEMENTS OF THE PUEBLA APPROACH

The experiences in the Puebla Project, supplemented by findings of similar programs elsewhere, indicate that such regional agricultural programs must function effectively in at least four major activities: (a) agronomic research, (b) technical assistance to farmers, (c) socio-economic evaluations, and (d) coordination of all activities touching directly on crop production. A team of specialists from related disciplines also should be available to advise Project technicians on a continuing basis. The regional agricultural program structure should have certain basic characteristics, including: (a) capable, highly motivated, well-trained staff; (b) incentives that make the work professionally rewarding to the staff; and (c) a budget that is adequate both in amount and ease of administration of funds. Each of these essential elements is discussed briefly in the following sections.

Agronomic Research

Agronomic research serves the regional program in testing the performance of crop varieties, and in determining the appropriate packages of production practices for different conditions in the area. In general, the amount of research required is proportional to the ecological variability in the area. For example, more research will be required in rainfed areas where the frequency and intensity of drought are high and variable within and among years, than in areas with irrigation or very favorable rainfall.

Major steps in conducting agronomic research:

(a) Gather and evaluate materials and information related to the technology used by the farmers in the area.

(b) Analyze existing technology for modifications that are most likely to produce increases in production and net income, and list in order of priority the technological questions for investigation.

(c) Plan and carry out field trials based on above priorities, taking into account the ecological diversity of the area.

(d) Harvest the trials, analyze the data, and express the results as production functions, response curves, or treatment means.

(e) Estimate the risks farmers take in using different levels of costly inputs, using the information that is available on climatic variability and the fluctuation in prices.

(f) Develop recommendations for different levels of investment in inputs and for different ecological conditions, taking into account the expected risk in production and marketing.

Recommendations produced after 1 year of research are an approximation to those needed in the area. In regions with irrigation or very favorable rainfall, this first approximation may have an acceptable level of precision. For rainfed regions with greater ecological diversity, continued agronomic research for one or more years will usually be necessary.

Technical Assistance to Farmers

When adequate crop production information is available, the regional agricultural program should develop a system to promote farmer use of the new technology, whereby:

(a) Farmers would be informed of the new recommendations, of the expected increases in yield and net income, and of the necessity for using all components of the technology precisely to obtain maximum results. Major communication media used for this purpose in Puebla were:

Radio and pamphlets: particularly useful in convincing the more advanced farmers to use the new technology. Television and newspapers were little used in Puebla as they reach a very small fraction of the rural population;

Village meetings: effective in reaching the less advanced farmers. The new recommendations were explained in detail. Movies were used to attract people to the meetings, to strengthen the presentation on technology, and to provide farmers with information on related areas of interest.

Field demonstrations of technology: new practices demonstrated to the farmers directly in the field. Demonstrations were held at planting time and at the second application of nitrogen. A group of farmers met in a field farmed by a group member; the technician demonstrated the new way to plant, fertilize, etc.; and all farmers then participated in the operation. Demonstrations were particularly useful in convincing farmers to use the technology correctly.

Interchange of farmer groups: farmers of one village invited farmers from other villages to visit their plantings during the crop growing season. Farmers from the different villages exchanged experiences about maize production and other farming and non-farming activities. The technician accompanied the farmers on a walking tour of several adjoining fields. Deficiencies and favorable aspects of each planting were pointed out and discussed. These group interchanges contributed to a better understanding of maize production and also generated discussion about many other activities.

Field demonstrations at harvest: included local demonstrations (attended by farmers from a few villages) and regional demonstrations (attended by farmers from the entire Project area). The effects of different combinations of production practices on yield were demonstrated, along with costs and returns obtainable from different technologies. The farmer owning the demonstration field assisted in presenting the results.

(b) Farmers would be assisted in arranging for the inputs needed to use the new technology. Many farmers can purchase seed, fertilizers, insecticides, etc. with their own money, or they can obtain funds from a lending agency. Others, however, are able to use technology involving expensive inputs only if credit is made available. Technicians in the Puebla Project assisted in arranging for credit and fertilizers by:

Organization of farmers into groups: individual small farmers normally can not qualify for credit from a public or private bank. However, a properly organized group of small farmers can qualify. Thus, in addition to promoting the new technology, technicians encouraged farmers who needed credit to organize into groups. Information was provided about organizational requirements to obtain credit from different institutions.

Establishing relationships between groups and credit banks: organization of the farmers and instructions on how to present their request for credit were complemented by the technicians' initial accompaniment of the group to the bank to support their application for credit. Without such support, groups of small farmers often made numerous trips to the bank before completing arrangements for credit, or decided that the credit process was too troublesome.

Developing group capability: leaders of the groups were encouraged to accept responsibility as rapidly as possible for all activities of the groups, including transactions with the credit banks. The technician continued to provide the groups with information and ideas, but the decision-making was done by the groups. The Puebla Project experiences indicate that this effort by the technical team to develop the capability of the groups needs to be strengthened. It is clearly necessary to plan and carry out a systematic training program for the farmers, particularly the group leaders, that will assist them in obtaining the knowledge and skills they need in resolving their common problems more effectively.

(c) Farmers would be assisted in resolving other problems that prevent them from using effectively the crop recommendations. Such problems may arise due to dissatisfaction with the requirements of the credit banks, the operating procedures of the crop insurance agency, the way their farmer organization is functioning, etc. These problems can often be eliminated, if fully understood and properly presented to the people with authority to resolve them. The Puebla technical assistance agents were in daily contact with the farmers, learning about their needs, limitations, and problems. This information, collected from farmers in many villages, was transmitted back to the other members of the Project team. The team studied the information and decided what action to take. Usually it was necessary to collect additional information from farmers, services agencies, or both before deciding on a course of action. The Project coordinator would then take the initiative in promoting the necessary action for bringing about change.

Evaluations

The specific responsibility for identifying problems and suggesting solutions is assigned to one member of the Project team, the evaluator. He takes the leadership in synthesizing the information that flows from the farmers through the technical assistance agents to the team. This leads to the identification of questions, often with respect to both farmers and institutions, that need further study and clarfication. The evaluator plans and conducts studies to obtain the information needed.

After all the available information about a given problem has been assembled, the evaluator, assisted by the rest of the team, plans a strategy for working out a solution to the problem. This may involve action primarily by the technical assistance agents in providing new information to the farmers or assisting them with organizational changes. In other cases, it may be necessary for the team, usually represented by the coordinator, to interact directly with the representatives of one or more of the service agencies in finding a satisfactory way to modify operating procedures. These strategies represent a major source of new ideas for the constant improvement of the plan of operations of the agricultural program.

The Puebla Project has had one member of the team, well-qualified to carry out socioeconomic evaluations, who has assumed the responsibility for identifying, studying, and helping resolve problems limiting farmer use of the new technology. In larger programs, this function may require more than one person.

A second major responsibility of the Puebla Project evaluator was the collecting, analyzing, and interpreting of the data needed to measure progress in the Project. This involved the collection of data on the socioeconomic characteristics of the farming population and their agronomic practices at the beginning of the program, and at least one other similar study after the program had been operating for an appropriate period.

It can be argued that the function of evaluating progress in an agricultural program should be assigned to an outside agency. Regardless of how this evaluation function is handled, however, it is necessary that the socioeconomic data collected in the surveys be made available to the program evaluator as promptly as possible.

Coordination

Perhaps the most complex function in a regional agricultural program is the coordination of the activities of farmers, program staff, and service institutions. In Puebla, the coordinator performed three distinct but closely related roles:

(a) Administration of the program: was responsible for the hiring of Project staff, participated in defining policy on personnel matters, approved the expenditure of funds, etc.

(b) Direction of the program: personally directed the activities of the staff in the preparation of detailed plans of operation, the execution of these plans, and the summarizing and reporting of accomplishments. Important matters affecting the functioning of the program were fully discussed by the members of the team before the coordinator made a decision.

(c) Acquisition and maintenance of the support of the institutions that can assist in achieving the goals of the program: informed the representatives of the institutions of the plans of the program, its accomplishments, and the needs of the farmers. When problems arose that required action by the institutions, he provided relevant information and worked closely with them in finding a solution.

Technical Backing for Program Staff

The staff members in a regional agricultural program should interact on a continuing basis with highly trained and experienced technicians who are active in their respective fields. The field staff will normally be composed of capable young people with good fundamental preparation but with little specialized training or previous experience. These young technicians will need guidance from more experienced people in preparing detailed plans of operation, selecting the best procedures for their work, resolving social and technical problems that arise during the execution of programs, and analyzing and interpreting the results of their endeavors.

In Puebla, the Project staff received technical assistance from specialists at the Graduate College at Chapingo and CIMMYT, and from a sociologist working with a private organization. Countries that choose to undertake regional agricultural programs of the Puebla type will need to develop a corps of highly trained and experienced technicians who can provide backing to the staffs in the regional programs. Initially, this technical backstopping might be provided by a corps of experts from another country that are familiar with local problems. As the regional program staffs in a country become more experienced, however, the country can organize its own team of technical advisors. The advisory team should be a part of the national research and extension organization or of a national institution of higher education in agriculture. It is expected that the team of advisors will both provide assistance to program teams and participate in the training of staff for such programs.

As the number of regional programs in a country becomes larger, it will probably be necessary to partition the country into two or more zones, and to organize a team of advisors for each zone. Again, it is expected that these teams will have the responsibility for both technical assistance and training within their corresponding zones.

Capable, Highly Motivated, Well-Trained Staff

Successful regional agricultural programs require a dedication of time and effort by the staff far above that necessary in most technical and professional careers, due to the large number of farmers and groups served. The personnel selected for these programs should be highly motivated to know and understand the farmer, his family, and community; and to assist them to improve their production, net income, and general welfare.

In addition, the team members of a small farmer program should have personalities enabling them to gain and hold the confidence of the farmers and to work harmoniously with their coworkers. They should have the academic background and capability for rapidly learning the technology corresponding to their jobs, for applying this knowledge effectively, and for identifying new problems and proposing ways to solve them.

New team members should be instructed in the general aspects of the program (philosophy, objectives, characteristics of the area, accomplishments, etc.) and the specific techniques that each will employ in his particular part of the undertaking. Some of this training can be given in formal classes and discussions, although most of it should be done in the field, with the trainees assuming direct responsibilities in the program (closely supervised by experienced people).

Incentives

One of the principal incentives for young professionals to participate in small farmer programs is the opportunity to use their talents for improving the welfare of this disadvantaged sector. Nonetheless, the agricultural program should provide working conditions and opportunities that enable its staff to work effectively and advance professionally, including:

(a) Salaries and perquisites that are competitive with other employment opportunities.

(1) Timely availability of the necessities for getting the job done (adequate operating expenses for vehicles, prompt purchase of equipment and supplies, revolving funds for the purchase of small items, prompt repair of vehicles and equipment, etc.)

(c) Encouragement to use their own initiative and innovativeness. The staff cannot be provided with a manual of operation that covers every exigency that may arise. The team members must be encouraged to work out their own solutions when confronted with a new problem, and to follow up, when necessary, by seeking appropriate advice from the rest of the staff and advisors. Decisive problem-solving should be encouraged, with some mistakes to be expected as part of the process.

(d) Opportunities for advancement: outstanding team members should have the opportunity to advance both in salary and responsibilities either in the same or a different program. Also, those so inclined should be assisted in continuing advanced academic training after participating for a few years in an agricultural program.

An Adequate Budget

Agricultural programs for small farmers should be adequately funded, with budgets that provide for:

(a) Adequate staff, competitive salaries, mobility of staff, supplies and equipment, etc.

(b) Availability of funds when needed, a measure that can be expedited by delegating the responsibility and authority for dispensing funds to the program coordinator.

PROGRAM STRATEGIES

Efficiency of the regional agricultural programs will depend on their success in properly focusing the four essential activities (research, technical assistance, evaluation, coordination) and allocating to each the appropriate amount of resources to produce the greatest marginal returns. The term focus is defined as the way a given activity employs its resources (for example, technical assistance may choose to devote widely varying degrees of effort to organizing farmers and assisting them to obtain credit). Returns are measured in units of progress toward the goals of the program (number of participating farmers, degree to which participating farmers employ the recommendations correctly, increase in average yield, etc.). The strategy of a given program is the particular way in which the essential activities are organized and conducted, and takes into account both the amount of resources allocated for each activity and how they are used. A program may vary its strategy from year to year, and even from one season of the year to another.

Thus, a successful regional agricultural program should combine all essential elements with an efficient strategy for employing the essential activities. Experiences in the Puebla Project provide some insight into how the choice of a program strategy is influenced by the characteristics of the physical environment, stage of development of the infrastructure, political environment, size, diversity, and accessibility of the program area, and the existence of high-yielding varieties.

Influence of the Physical Environment

Intuitively, program planners can agree that the characteristics of the physical environment should be taken into account in selecting program strategies. Needs of an irrigated area, for example, are obviously different from those of a semi-arid region. Although experience is too limited to provide the expression of these relationships in quantitative terms, the experiences in Puebla and other programs can be used to suggest ways in which strategies may differ in programs conducted under several ecological conditions. Some of these suggestions are cited next.

A large part of the agriculture in Central Mexico is practiced in valleys and plains that lie between 1,500 and 2,800 m above sea level. The average annual precipitation in these areas varies from less than 500 mm to over 1,000 mm and falls largely in the period from May to October.

For illustrative purposes, these agricultural lands have been partioned into four categories as shown in Table 14.1. Drought frequencies for maize and levels of risk for maize and forage grasses shown here were based largely on studies conducted in the Bajio region of central Mexico during the period from 1962 to 1966.

Category A in Table 14.1 includes irrigated lands and areas with favorable rainfall. Drought in maize is infrequent and the level of agronomic risk is low. A satisfactory level of precision in crop recommendations can often be obtained by extrapolating from experiences in similar areas. In other cases, one year of research in the area may be needed to provide reliable agronomic information.

Category B consists of rainfed areas receiving 750-900 mm of precipitation annually. In a 10-year period, severe drought in maize can be expected 1 to 2 years, with moderate drought in another 2 to 3 1/2 years. These drought effects produce a level of risk for the maize producer that can be expressed qualtitatively as *intermediate* or *moderate* risk. The Puebla Project is located in a category B region. Depending upon the initial yield levels, it is expected that improved technology can increase average maize yields something like 100 percent in areas of this category. Pro-

Table 14.1. Estimated drought frequencies for maize, and levels of agronomic risk for maize and forage grasses, for four categories of land in central Mexico.

Category*	Drought in maize: Frequency (% of years)	Drought in maize: Intensity**	Level of agronomic risk: Maize and similar crops	Level of agronomic risk: Forage grasses
A. Irrigated land and rainfed areas with more than 900 mm of annual rainfall	0-10 % 0-20 %	severe moderate	Low	Very low
B. Rainfed areas with 750-900 mm of annual rainfall	10-20 % 20-35 %	severe moderate	Moderate	Low
C. Rainfed areas with 600-750 mm of annual rainfall	20-40 % 35-40 %	severe moderate	High	Moderate
D. Rainfed areas with less than 600 mm of annual rainfall	>40 % remainder	severe moderate	Very High	High

* These categories are defined for deep soils (medium and heavy soils more than 50 cm in depth; light soils more than 75 cm in depth). In general, with a given amount of rainfall, the effect of drought is inversely proportional to the altitude.

** Severe drought is arbitrarily defined as drought that reduces the potential yield by 60% or more; moderate drought as that which reduces the potential yield by 30 to 60 %.

gram strategy should place major stress on local research during the first year or so, and later on technical assistance with emphasis on work with farmer groups.

Category C of the same table includes rainfed areas receiving 600-750 mm of precipitation annually. In a 10-year period, the expected frequency of severe drought in maize is 2 to 4 years, with moderate drought in about 4 additional years. Farmers who grow maize in Category C regions assume a *high* level of risk.

Present indications are that average maize yields in a Category C region can be increased relatively little, perhaps by no more than 50-75 percent. Thus, agronomic research should give special attention to improved production of other species, such as beans, sorghum, millets, and forage grasses. Research on maize should emphasize the breeding of drought-tolerant varieties and the use of moisture conservation practices (early fall plowing, planting on contour, mulches, low plant densities, wide row spacings, weed control, etc.). Research on animal production also should assume greater importance. Applied research in Category C areas will require relatively more resources for a longer period of time than in Category B areas. Hopefully, however, much of the research findings will be applicable in similar areas with little additional testing.

Technical assistance in a Category C area will probably have little importance during the first few years while technological packages are being developed through local research. During these years, the principal effort should be devoted to explaining the nature of the program, organizing the farmers into groups, and preparing them to accept new practices once they have been defined. Afterwards the resources devoted to technical assistance will be similar to those in a Category B area.

Category D consists of rainfed areas receiving less than 600 mm of precipitation annually. Maize can be expected to suffer moderate or severe drought damage every year. The level of risk in growing maize is too high to permit the use of costly inputs such as fertilizers. Agronomic research should be concentrated on forage crops for animal production. Major emphasis should be placed on increasing net income and employment through non-agricultural activities such as cottage industries, arts and crafts, public works, etc.

It seems reasonable to assume that agricultural areas in other parts of Mexico and other countries can be grouped into four similar categories. The amounts of rainfall or levels of other ecological variables that mark the limits between the several categories will have to be determined locally.

The Puebla approach seems to be applicable in regions corresponding to the four categories, but is not essential for Category A areas. It is expected that strategies used in programs within a given category will be similar, but may vary greatly among programs in different categories.

Influence of Infrastructure Development

The lack of roads, markets, inputs, or a favorable input cost: produce price relationship in a Project area would indicate that the regional agricultural program should concentrate its initial action on developing these essentials. Under such conditions, technical assistance and agronomic research would, to some extent, be supplanted, temporarily by specific action to develop roads, markets, a distribution system for inputs, or favorable change in the prices of inputs and produce. The absence of credit would not postpone normal program activities, but would imply that the coordinator may have to devote considerable effort to making credit available in the area.

Influence of the Political Environment

The political entity, state or nation, sponsoring a regional agricultural program should be convinced of its merit before it approves the budget necessary for its operation. Political support for the program may become inadequate, however, when two situations arise: (a) political leaders may accept the importance of the program but fail to grasp the magnitude of the problem and become disillusioned when short-term accomplishments do not measure up to expectations, and (b) there is a change in the political leadership. Thus, it is necessary for the program strategy to include continuing action by the coordinator to keep the political leaders well-informed about program activities, difficulties, and accomplishments. The effort required will be greater when political support for the program is low.

Influence of Size, Diversity, and Accessibility of Program Area

The size of the staff and budget of a regional agr
program will generally be proportional to the cı
area and the number of farmers to be serviced by
gram. The experience in Puebla suggests the f
examples of staff assignments for programs with (
sizes of project areas:

(a) 25,000 ha would require a coordinator wh
responsible for technical assistance in a paı
area, one technical assistance agent, one te
responsible for agronomic research, and on
cian in charge of socioeconomic evaluations

(b) 50,000 ha would require a coordinator,
three technical assistance agents, one ag
research technician, and one evaluator.

(c) 100,000 ha would require a coordinator, f
nical assistance agents, two agronomic
technicians, and one evaluator.

(d) 200,000 ha would require a coordinatoı
sistant coordinator, 10 technical assistance
three or four agronomic research technici
one or two evaluators.

The number of technical assistance agents will be determined more by the number of farm families than by the amount of cultivated land. In Puebla, each technical assistance agent, assisted by one to two aides, was responsible for about 10,000 farm families.

The diversity of the area—variability in soils, physiography, temperature, and rainfall—mainly influences the problem of developing reliable technological packages. For a given size of area, the number of agronomic research technicians will generally increase as the diversity of the area increases.

In the previous examples it was assumed that the areas were easily accessible by mechanized transport. Under such conditions, a technical assistance agent will be able to reach the most remote village in his area in about an hour. For areas with poor communication, relatively larger staffs will be needed.

High-yielding Crop Varieties

High-yielding maize varieties, both native and improved, were available in Puebla when the Project was initiated. It seems unlikely, however, that this will always be the case. When crop varieties are not available that will permit farmers to greatly increase yields (e.g, double average yields in a Category B area), agronomic research should support development of such varieties. The central role of the regional program might be that of assisting a plant breeding team at a research center by collecting genetic materials from the program area, providing information on farmer and market preferences, and testing promising materials in the area.

THE REGIONAL AGRICULTURAL PROGRAM AS A FIRST STEP IN RURAL DEVELOPMENT

It was recognized from the beginning of the Puebla Project that the long-range objective was to improve net income, employment, and the general welfare of the rural people. That is, action to increase basic food crop production was seen as an initial step in the development of the rural population.

The experiences in Puebla support the proposition that rural development can be initiated effectively through an action program aimed at increasing the production of one or more basic crops. With a given amount of resources, a program for small, subsistence farmers is more likely to be successful if it concentrates its efforts on one or a few farming enterprises. By proving that the use of new technology leads to higher yields and net income, the program establishes its credibility and gains the confidence of the farmers. Once the program is accepted by the rural people, they become more receptive to the entrance of other programs that can contribute to a better way of life. The initiative for starting new programs may often come from the farmers themselves. Thus, step by step, an agricultural program is transformed into an integrated rural development program.

By early 1970, the Puebla staff felt that it would be appropriate to begin to give attention to other farming activities. The need to broaden the scope of Project activities was felt most acutely by the technical assistance agents, who sensed the eagerness of the farmers to improve all of their farming enterprises. Because the Puebla Project was programmed and financed specifically to increase maize production, however, other activities could not be expanded greatly (except for a small effort in bean production). Since 1970, the farmers have steadily increased pressure for the Puebla Project to provide assistance in fruit culture, the production of vegetable crops, the perforation of wells for irrigation, animal production, etc. The Puebla staff is in agreement that momentum in the maize production effort has been lost due to the inability of the Project to respond to these other production concerns.

Thus, the Puebla experience indicates that a rural development program can be launched effectively by concentrating initially on rapidly increasing the production and net income from an important basic food crop. After a portion of the farmers have successfully used the new cropping practices, the program should proceed immediately to expand to other activities. The rate at which an agricultural program is gradually transformed into an integrated rural development program may differ from village to village, and should reflect the desire and readiness of the rural people to undertake new activities.

APPENDIX A

A BENEFIT: COST ANALYSIS OF THE AGRONOMIC RESEARCH PROGRAM

The question has been raised as to whether or not the Puebla Project has placed too much emphasis on agronomic research. A partial answer to this question is provided in this section in the form of a summary of costs and some benefits associated with this program.

The costs involved in producing the limited capital and unlimited capital technologies are summarized in Table A.1. These include all costs of operation – salaries, equipment, materials, vehicles, etc. – plus consulting services.

TABLE A - 1. The cost of generating the maize technology of the Puebla Project.

Year	Costs of operation	Consulting costs	Total*
1967	18,294	6,245	28,956
1968	25,512	5,600	36,713
1969	28,945	9,293	45,121
1970**	30,534	5,230	42,201
1971**	32,039	3,142	41,513
Total	135,324	29,511	194,504

* Includes an overhead administrative charge of 18%.

** Eighty percent of operating costs and 64% of consulting costs were assigned to agronomic research on maize. The remaining costs were allocated to research on beans and the maize-beans association.

Agronomic research in 1970 and 1971 included, in addition to field trials with maize, work with beans and the maize-beans association. In these years, therefore, only 80 percent of the operating costs of the agronomic research program and 64 percent of the consulting expenses were considered as costs of generating the maize technologies.

When we refer in the following paragraphs to the benefits associated with the project technologies, it must be kept in mind that what we call benefits, are really the confounded effects of the production technologies plus the interaction between these technologies and the other components of the project (coordination, technical assistance, and evaluation).

In estimating the benefits associated with the project technologies, it was assumed that the Puebla Project might have adopted either of two strategies: (1) use the information on improved maize production practices available in 1967, the INIA technology, and devote its resources exclusively to technical assistance, coordination, and evaluation: or (2) choose, as it did, to include agronomic research as an integral part of its activities. The difference in cost of the two strategies is $194,504, as shown in Table A.1. The difference in benefits with the two strategies is obtained by subtracting the net benefits using the INIA technology from net benefits using the limited or unlimited capital technologies.

A net benefit, as used here, is the value of the net increase in yield (both grain and stover) with one of the improved technologies, less the value of the net increase in yield using the traditional technology, with both estimated for the same area. That is, net benefits using an improved technology are benefits over and above those obtained with the traditional technology.

In calculating benefits it was assumed that the rate of adoption of INIA and project recommendations would be the same. This assumption tends to favor the INIA technology inasmuch as the efficiency of this technology, as discussed earlier, is inferior to that of the Project recommendations. The values of the net increases in yield per dollar invested in fertilizers, for example, are 1.45, 1.94, and 1.62 for the INIA, limited capital, and unlimited capital technologies, respectively, as shown in Table 3.15.

To estimate total net benefits with the three technologies, it was further assumed that benefits would accrue over the 20-year period 1967-1986, and that adoption of the technologies would occur in the following manner: (1) for the years 1968-1973, the areas of adoption would be equal to those planted to maize by farmers on credit lists (see Table 9.6); and (2) for the period 1974-1986, the area of adoption would increase each year by 3.3 percent, the average increase in adoption by farmers on credit lists in 1971-1973.

Maize prices paid by the National Marketing Agency at their warehouses were $75.20 per ton in 1968-1972 and $96.00 per ton in 1973. It was assumed that the Agency would continue to purchase maize at the latter price during the years 1974-1986. The prices for maize used in estimating benefits were calculated by discounting the above prices for costs of harvesting, shelling, sacking and transport. These prices for maize in the field were $54.80 for the 1968-1972 period and $78.80 for 1973-1986. A price of $5.60 per ton was assigned to maize stover.

The net benefits attributable to the INIA and unlimited capital technologies for the 1967-1968 period are shown in Table A.2 as unadjusted additional benefits. The annual benefit values were adjusted to their corresponding values in 1967, assuming that capital would grow at an annual rate of 14 percent, and that the currency would decrease in value at a rate represented by the price indices published by the Bank of Mexico. This adjustment was made by multiplying the unadjusted values for a given year by the appropriate discount factor (Table A.2) and dividing the product by the relative price index. Research costs were adjusted to 1967 values in the same manner.

The total adjusted cost of the research for producing project recommendations for maize was $140,930. The total adjusted net benefits using the INIA and unlimited capital technologies were $2,556,224 and $5,634,691, respectively. The difference between the total adjusted net

TABLE A–2. Cost of agronomic research and estimated benefits from using the INIA and unlimited capital technologies, in addition to those produced by the traditional technology.

Year	Discount factors*	Price indices**	Research costs		Percentage of area using technology ++	Additional benefits °			
						INIA		Unlimited capital	
			Unadjusted	Adjusted+		Unadjusted	Adjusted+	Unadjusted	Adjusted+
1967	1.0000	1.000	28,956	28,956	0	0	0	0	0
68	0.8772	1.019	36,713	31,604	0.1	1,471	1,266	3,237	2,787
69	0.7695	1.045	45,121	33,226	7.3	107,392	79,080	236,301	174,003
70	0.6750	1.107	42,201	25,733	15.8	232,437	141,730	511,446	311,857
71	0.5921	1.148	41,513	21,411	18.0	264,802	136,576	582,660	300,517
72	0.5194	1.181	0	0	21.9	322,175	141,692	708,903	311,773
73	0.4556	1.276	0	0	25.8	534,576	190,872	1,179,576	421,171
74	0.3996	1.276	0	0	29.1	602,952	188,824	1,330,452	416,653
75	0.3506	1.276	0	0	32.4	671,328	184,457	1,481,328	407,017
76	0.3075	1.276	0	0	35.7	739,704	178,259	1,632,204	393,341
77	0.2697	1.276	0	0	39.0	808,080	172,012	1,783,080	376,878
78	0.2366	1.276	0	0	42.3	876,456	162,515	1,933,956	358,600
79	0.2076	1.276	0	0	45.6	944,832	153,720	2,084,832	339,194
80	0.1821	1.276	0	0	48.9	1,013,208	144,597	2,235,708	319,061
81	0.1597	1.276	0	0	52.2	1,081,584	135,368	2,386,584	298,697
82	0.1401	1.276	0	0	55.5	1,149,960	126,261	2,537,460	278,604
83	0.1229	1.276	0	0	58.8	1,218,336	117,346	2,688,336	258,931
84	0.1078	1.276	0	0	62.1	1,286,712	108,705	2,839,212	239,864
85	0.0946	1.276	0	0	65.4	1,355,088	100,463	2,990,088	221,679
86	0.0829	1.276	0	0	68.7	1,423,464	92,481	3,140,964	204,064
Total				140,930			2,556,224		5,634,691

* Calculated using the formula for compound interest: $f = \frac{1}{(1+0.14)^i}$, where i = 0,1, ..., 19.

** The price indices for 1967 through 1973 were taken from Indicadores Económicos, Gerencia de Investigación Económica, Banco de México, S.A. Vol. I, No. 6. May 1973. Since price of maize was assumed to be constant in the period 1973-1986, no addition corrections for changes in price indices were made after 1973.

\+ The adjusted cost or benefit was calculated by multiplying the unadjusted value by the discount factor and dividing the product by the price index.

\+ + The values for 1967-1973 are the percentages of the total area in maize, 80,000 ha, planted by farmers on credit lists. It was assumed that from 1974 onward, there would be an annual increase in the area of adoption of 3.3% , the average yearly increase in 1971-1973.

° The unadjusted benefits are the differences between the net increase values using the INIA or unlimited capital technology and the net increase values using the traditional technology.

benefits using the INIA and unlimited capital technologies is $3,078,467. This is the net benefit attributable to the research carried out in generating project recommendations for maize production. The benefit: cost ratio for the agronomic research on maize practices is 21.84.

Benefits as estimated in Table A.2 for unlimited capital do not include all the benefits derived from agronomic research. A benefit of perhaps equal importance is the detailed information on maize production relationships that has been produced. Such information has many uses. At the present time, for example, there is an energy shortage in most parts of the world and there are prospects of fertilizer rationing. The information that has been produced on maize production relationships can be useful in deciding on the most efficient way to employ a limited amount of fertilizer in the Puebla area.

The limited capital technology is an example of how a scarce resource such as fertilizer can be allocated efficiently. The total adjusted net benefits using the limited capital technology, calculated as described earlier, were $3,038,683. The difference between this value and the total adjusted net benefits with the INIA technology is $482,459; this is the benefit attributable to agronomic research. If the limited capital technology were the only contribution of the research program, the benefit: cost ratio would be 3.42.

The use of the limited capital technology instead of the INIA technology over the period 1967-1986, with the rate of adoption shown in Table A.2, would represent a saving of 15,774 tons of ammonium sulphate and 69,141 tons of simple superphosphate. This amount of ammonium sulphate is equal to 53 percent of that needed each year to fertilize the 80,000 ha in the Puebla area, using the limited capital technology. The 69,141 tons of simple superphosphate is sufficient to fertilize according to limited capital technology all maize plantings in the Puebla area for a period of 11 years.

A further benefit derived from agronomic research has been the feeling of confidence on the part of the Project staff, the representatives of the service institutions, and the farmers, that maize yields can be greatly increased and with economic benefits to the farmers. This confidence in the maize technology has undoubtedly contributed significantly to a more rapid rate of adoption of Project recommendations by the farmers.

Finally, the educational benefits resulting from the agronomic research should be mentioned. The Project staff that conducted the research and many Latin American agronomists who received training in Puebla, benefited from their participation in the program. Professionals trained in Puebla have been responsible for agronomic research in similar regional programs in Honduras, Colombia, Peru, and the states of Mexico and Tlaxcala in Mexico. In general, their experience in Puebla has enabled them to achieve greater efficiency in developing improved technology, as compared to that realized in the early years in Puebla.

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