AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 72

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AE10-0000-0000

B. SECONDARY
Agricultural economics

2. TITLE AND SUBTITLE
Strategies for increasing agricultural production on small holdings

3. AUTHOR(S)
(100) Myren,D.T.; (101) Conf.on Strategies for Increasing Agricultural Production on Small Holdings,Puebla,Mexico,1970

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	89p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
CIMMYT

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER
PN-RAB-766

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Farms,small
Maize
Meetings
Mexico.
Puebla project
Productivity
Strategy

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1083 GIS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Office of Agriculture
Bureau for Technical Assistance
Agency for International Development
Washington, D. C. 20523

TA/AGR REFERENCE LIBRARY

strategies for increasing agricultural production on small holdings

International Conference, Puebla, México
August 1970

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 México 6, D. F., México

contents

Page

3 Preface

5 The urgency of accelerating production on small farms. *E. J. Wellhausen.*

11 The Puebla Project: A regional program for rapidly increasing corn yields among 50,000 small holders. *Leobardo Jiménez.*

19 Rapid increases in corn yields on small irrigated holdings in the region near Chapingo, México. *Abdo Magdub, Alberto Zuloaga.*

27 The program of the Foundation for Promotion of Cooperatives (FPC) in El Salvador. *José Romeo Maeda, Jesús Merino Argueta, Sebald Manger-Cats.*

35 Value of agronomic research in a project to rapidly increase corn production. *Antonio Turrent.*

43 Methodology and Results of Evaluation in the Puebla Project. *Heliodoro Díaz, Juan Manuel Rangel.*

51 Cost-benefit analysis of the Puebla Project. *Delbert T. Myren, Jairo Cano.*

63 Philosophy and operating principles for a program aimed at increasing crop yields among small holders, based on experience in the Puebla Project. *Leobardo Jiménez.*

69 A summary of what we have learned about increasing productivity among small land holders. *Eduardo Alvarez Luna.*

73 Possible roles of CIMMYT in national programs to obtain rapid yield increases. *Reggie J. Laird.*

79 Open discussion of possible roles of development agencies in raising yields among small farmers. *Keith W. Finlay* (presiding).

85 Visit to the Puebla Project.

86 Participants.

edited by:

DELBERT T. MYREN

preface

The proceedings recorded here are the result of two international conferences held in early August, 1970, in the City of Puebla, Mexico. The theme of both meetings was the same: "Strategies for increasing agricultural production on small holdings". The first conference, held in Spanish from August 3-5, was attended by more than 120 agricultural technicians from Mexico and 14 other Latin American countries. The second held in English on August 6 and 7 drew participants from 15 international development organizations

The urgent question confronting the participants in both meetings was how to incorporate the small holders into modern agriculture. It was recognized that these farmers have a key role tc play in terms of national food production and that by adopting modern agricultural methods they might also improve their own levels of living.

For the first conference an effort was made to invite a balanced group of professional workers mainly from the countries where the joint problem of small holdings and low yields is most accute. Following this criteria, in general three outstanding individuals were invited from each country: one from a key position in a government planning post of central bank, an agronomist actively engaged in agricultural research, and a man actively involved in extension or in agricultural infrastructure, such as credit, fertilizer distribution, or marketing In a few cases where a strong interest had developed in this problem, the countries financed the travel and per diem of additional participants.

Clear-cut norms were established as to the kind of participants desired. Before extending invitations the potential participants were informed of the goals of the conference. This would not be just one more discussion of the problems of the small holders. This would be a meeting of professional workers with a sincere interest in doing something about the problem and in a position where potentially they might contribute to its solution. Also there should be a next stage —the formulation of a specific development project to be proposed for financing to their respective governments or private or international organizations. There would be some opportunity during the conference for discussing preliminary proposals. In addition, an outline was sent ahead to serve as a guide for organizing ideas and collecting preliminary data. It was made clear that each participant should have a defined interest because only in this way would it be possible to focus the discussion on concrete methods and objectives The result of these pre-conditions was a surprisingly frank discussion of the short-comings of past programs and a rather well focused discussion of ways to make future strategies more effective. There appeared to be a complete awareness of the problem, and the participants came with the clear purpose in mind of discussing possible alternative strategies for attacking the problem.

The second conference, reported in this proceedings issue, brought together high level representatives from 15 international organizations involved in agricultural development. Here again it was found that the international dialogue that has been going on about the urgency of raising yields on small holdings has reached the point where most

professionals are in agreement on the need. The participants were ready to get down to a specific discussion of strategies. Much of the discussion focused around questions of what was unique about the strategies employed in the three case studies presented and which, or how much, of them might be fruitfully employed in other areas with similar problems.

A separate proceedings issue is being published for each meeting. The content of the papers presented at the Spanish meeting is identical, but the discussions, of course, are different. The English discussions recorded in this issue are based largely on notes taken by Dr. Gregorio Martínez and have been edited to present as concise a summary as possible of the points covered.

This English edition includes only the English papers and discussions presented on August 6 and 7. In the discussion, only the last name of the speaker is recorded. Full names and positions appear in the list of participants at the conclusion of this report.

The conferences were sponsored jointly by the Mexican Ministry of Agriculture, the Government of the State of Puebla, the Graduate College of the National School of Agriculture at Chapingo, the National Institute for Agricultural Research and the International Maize and Wheat Improvement Center (CIMMYT). The costs of travel and per diem for many of the participants and the publication of these proceedings, were covered in large part by a grant of US$24,600 from the Rockefeller Foundation.

The first conference was inaugurated by the Secretary of Agriculture, Prof. Juan Gil Preciado and an official welcome was given by the Governor of the State of Puebla, Dr. Rafael Moreno Valle. The conferences were officially closed on August 7 by the Sub-Secretary for Agriculture, Ing. Ricardo Acosta Velasco. All three of these official statements are included in the Spanish Proceedings.

In order to facilitate international comparisons, unless otherwise indicated monetary values in this report are expressed in US dollars and weights are expressed in the metric system.

the urgency of accelerating production on small farms

E. J. WELLHAUSEN [1]

DURING THE LAST two decades tremendous progress has been made in agricultural production in the developing areas of the world. Never before has so much progress been made so quickly.

Since 1950, wheat production in Mexico has increased from around 300,000 tons to approximately 2.5 million, about 8 fold. Yields per unit area increased from 800 kg/ha to about 2,800 —more than 3.5 times. The average yield for the important wheat producing states of northwest Mexico is now over 3,600 kg/ha. During the last few years, Mexico has limited the acreage planted to wheat to prevent unmanageable surpluses.

Similarly, but somewhat less spectacularly, maize production increased by more than 250 percent in the last two decades —from 3.5 million tons in a good rainfall year in the late 1940's to about 9 million tons in a good year like 1968. During this same period, average yields per hectare doubled, from 700 kg/ha to about 1,400.

Sorghum production is perhaps ever more striking, having grown from about 30,000 tons to 2 million tons, with most of the increase during the last decade. During the last two decades, Mexico has become self-sufficient in its basic food and feed grains, with a population that almost doubled during the same period.

These are extraordinary achievements and have been referred to in international circles as the "Green Revolution". These advances can be attributed in large part to a combination of three factors:

1. High yielding, widely adapted, fertilizer responsive, disease resistant varieties;
2. An improved package of cultural practices, including better land management, adequate fertilization and better weed and insect control which permitted these varieties to more fully express their high yield capabilities, and
3. A favorable relationship between the cost of fertilizer and other inputs and the price the farmer received for his product —perhaps the most important factor of all.

In the case of corn, the high yielding varieties in combination with improved cultural practices and good moisture conditions produced yields 50 to 100 percent greater than those obtained with traditional techniques.

The increases were even higher in the case of wheat, where a favorable relationship between the cost of new inputs and price of product afforded profit increases of nearly 100 percent. As a result, this new science-based technology spread very rapidly, without special promotion programs, among the com-

[1] Director General, CIMMYT, Mexico.

mercial farmers in areas where risks were at a minimum.

The power of this combination of factors in sparking an almost miraculous acceleration of wheat production is amply illustrated in India and Pakistan. With the seed and production technology imported from Mexico, Pakistan raised its total wheat production from 4.6 million tons to 8.4 —an increase of 83 percent in five years. Similarly, India, with the same varieties and production technology imported from Mexico, raised production from a high of 12 million tons in 1965 to over 20 mililon in 1970— and increase of 64 precent.

Rice production is a similar story. With the development and distribution of the new high yielding varieties, along with new production techniques perfected by the International Rice Research Institute at Los Baños, yields of rice have soared in many parts of South and Southeast Asia.

The Philippines attained self-sufficiency in five years with extensive plantings of the semi-dwarf variety IR8. Over a similar period, Ceylon increased production by 50 percent, and rice production has risen spectacularly in West Pakistan with extensive use of these new varieties and production techniques. In India, with the new varieties and improved technology rapidly coming into use, striking increases are expected during the next few years.

The forerunners of this green revolution in South and Southeast Asia are wheat and rice, but maize and sorghum —the other important food grains of the world— are running quietly behind.

Thailand set another high record in maize production in 1969. During the past decade, production has increased at the rate of about 52,000 hectares and 100,000 tons per year, using new high yielding varieties and cultural practices. West Pakistan reported a 30 percent increase in yield over the past year. India has boosted the area planted to maize from 40-50 percent since 1960 with yields per unit area steadily climbing. The new dwarf varieties of sorghum are moving almost as rapidly, especially in India and Pakistan. Altogether, the area planted to the new high yielding varieties of wheat, rice, maize and sorghum in South and Southeast Asia climbed from practically zero in 1964-65 to 15 million hectares in 1969-70.

These are almost miraculous accomplishments, never before attained in the history of the world, and along with them have come new hopes for the most heavily populated area of the universe. This experience has clearly demonstrated that the first problem in increasing production is not the changing of farmers' attitudes and ancient customs, but rather the developing of the appropriate technical production which will substantially increase yields and with favorable pricing policies allow the farmer to make a profit.

These results have surprised many influential people and have brought about a drastic shift in attitudes toward the possibility of the world feeding itself. Many countries in the Near East and North Africa such as Afghanistan, Iraq, Iran, Turkey, Tunisia, Algeria and Morocco have undertaken programs of self-sufficiency in wheat, based initially on the high yielding varieties developed in Mexico.

In South America, Brazil has launched a new science-based program with hopes of supplying its own requirements of wheat by tripling production from one million to three million tons. Since the Mexican varieties are not directly adaptable, Brazil has undertaken an extensive breeding program of its own as an essential first step. On the other hand, Bolivia and Ecuador hope to reach self-sufficiency soon with varieties developed in Mexico and Colombia.

The Green Revolution is spreading and many countries are aiming at self-sufficiency. There is no doubt that most food deficient countries can, with the proper technological package and government policies, become self-sufficient in their basic food grains. The question becomes not so much whether it can be done, but how it should be done, or whether from a purely economic standpoint, it should be attempted at all. In regard to this, each country will need to make its own decisions.

This is the bright side of the coin. But as we turn the coin over and look at the darker side, we find there is no time for complacency even in those countries of the developing world that have reached apparent self-sufficiency. Upon careful analysis, it is evident that the green revolution up to now, has moved ahead on its own momentum. It has become self-propelled primarily among the larger, more commercially-minded, well-established farmers. Furthermore, as one might expect, the new varieties and technologies have flourished and moved fastest in those areas where production risks were lowest and profit prospects the highest. All farmers have not benefited equally from this advance in technology.

In Mexico, wheat production is concentrated in the irrigated areas of the Pacific

Northwest and the central Bajio. New technologies in corn production, as could be expected, have been adopted first in the areas with best rainfall, among the larger, more commercial farmers. Sorghum, supposedly a crop for dry areas with highly variable rainfall, is being grown by the highly commercialized farmers in the better rainfall areas and often under irrigation.

In Guatemala, modern technologies in corn production tend to be used more in the Pacific lowland coastal areas. These areas can fully supply the needs of the cities —yet most of Guatemala's rural, corn-eating people live in the highlands where they attempt to produce their own food and eke out a meager existence.

Colombia has its rich valleys like the Cauca and the lowland plains of the northwest with a tremendous potential for food production using the new science-based technologies. However, most of the rural people live in the highlands.

Ecuador is trying to reach self-sufficiency in wheat by concentrating production in the two or three more favorable valleys and is markedly increasing its corn production in the Pacific coastal areas —yet most of the rural people are located in the highlands.

Peru has made a great impact with hybrid corn in the irrigated coastal area which has contributed to a tremendous increase in meat and egg production. However, the bulk of the rural people attempt to produce their food in the highlands with outmoded traditional methods.

Bolivia is attempting to supply its own requirements in wheat by applying the new science-based package in selected areas, and is increasing its corn production in the lowlands with composite varieties, introduced from Mexico. Here also, the supply of food will be increased in the cities but the large rural subsistence sector in the highlands will be by-passed.

Brazil has made substantial advances in corn production through the use of hybrid corn in the States of Sao Paulo, Parana and Minas Gerais, but little has been done in the poverty-stricken rural areas of the northeast. Although Brazil has almost unlimited land that can be brought into production, it is not likely that her rural problems can be solved by expanding into new regions without an attempt to increase production in some of the presently overcrowded rural areas.

Even Argentina is beginning to have its rural poverty problems. The ever increasing "chacareros" with relative small holdings are finding it difficult to make a living with their present production techniques. They will be forced to adopt the new science-based technology, along with help from a more favorable pricing policy if they are to make a fair living.

In most of the Latin American countries, the tendency is to concentrate the new scientific production package and investments in the more favorable areas with the better farmers From a purely economic standpoint, it is probably wise to direct the usually scarce credit resources to where they can be most efficiently used and return the largest dividends. But there is another aspect not always readily apparent Most countries have a threefold agricultural policy: (1) to provide sufficient food and fiber to meet national requirements at a reasonable price, (2) to produce crops that can be exported to bolster foreign exchange, and (3) to increase the standard of living and income levels of the rural masses —especially the low-income farmers and agricultural laborers.

This latter policy has become a major problem in most developing countries and it is being attacked in various ways, often without much success. One high level Mexican official recently pointed out that large sums have been invested in agricultural research, extension and educational institutions, that additional sources of credit have been found for the farmers, that large sums have been invested in irrigation projects, but still the problem of the small, non-commercial or semi-commercial farmer remains unchanged.

Although the fruits of all these efforts eventually may reach the small subsistence farmers, it is urgent that ways be found whereby the new science-based technology can be more rapidly extended to the large number of non- or semi-commercial farmers whose primary concern is producing enough for themselves and their families to eat. How to do this is the number one problem confronting the developing world today. In our turbulent revolution-ridden world, the time lag between improvements at one level of society and those at another must not be prolonged if explosive consequences are to be avoided.

For these reasons it is urgent to put a wider base under the green revolution and extend its benefits to a larger number of people in the rural sector. I would like to take the next few minutes to review for you some of the factors which contribute to this urgency.

First. As we have noted, most of the farmers in the developing world today are still in the subsistence or semi-subsistence class, despite tremendous advances in total food production. In pointing out the magnitude of this problem, I shall draw heavily upon examples in Mexico because I have resided in this country for the last 27 years and am more fully acquainted with its agricultural and social problems. By this, I do not wish to imply that the problems here are more acute than in other areas of the developing world. As a matter of fact, Mexico's gross national product has been growing at the rate of 6 percent per year. Few countries in the tropical and subtropical areas around the globe have been able to equal this advance. Also, I doubt that you will find any countries more desirous of extending the benefits of this progress to all its people.

In Mexico, as in other parts of the world, it is difficult to determine exactly who falls into the subsistence or semi-subsistence class of farming; however, it has been estimated that 30 percent of the farmers in this dynamic country produce 70 percent of the food. If these estimates are correct, about 70 percent of the farmers are still engaged primarily in producing at a subsistence level, enough to sustain a single family. Furthermore, it is estimated that this massive group of small subsistence farmers, together with their families and a large associated group of rural agricultural workers and their families, comprises approximately 20 million people or two persons out of every 5 in the entire Mexican population.

The situation in Latin America as a whole, exclusive of Argentina, seems to be even more serious. In studying the available statistics, it appears that about 50 percent of the people of Latin America depend largely upon a subsistence type of agriculture.

And in the world as a whole, the problem is even more ominous. If we define the subsistence farmer as one who uses most of what he grows to meet the needs of his own family, he is found wherever land is arable, on all three continents from latitudes of Alaska on the north to the southern tip of Argentina on the south. He may grow cassava in Africa, wheat and rice in South and Southeast Asia, and corn in the Americas. He almost always lives at a low standard and close to the edge of poverty.

It is even more difficult to determine the number of subsistence farmers in the world than it is to determine the number within any one country. Various estimates have been attempted, the most recent ones were made independently by Whittlesey and Woytinsky. Whittlesey, in a paper published in 1936, estimated that subsistence farming, hunting and fishing involved about 60 percent of mankind. Similarly, Woytinsky (1953) estimated that in 1948 about 55 percent of the world's population or about 1.4 billion people were involved in some form of subsistence economy. Although these estimates were made 20 to 30 years ago, it is doubtful if the numbers have been reduced. On the contrary, with a rapid growth in population since then, the numbers have probably increased. From this information I believe it is safe to conclude that more than one half of the people of the world depend upon a subsistence type of agriculture. When we take into account that this figure includes highly developed areas of the world in which less than 8 percent of the people are engaged in agriculture, it seems certain that some countries contain a very high percentage of people involved in subsistence agriculture. The plight of these masses of people is relevant to my second point.

Second. It is urgent to extend the new science-based technology to the subsistence farmer for purely humanitarian reasons. As I indicated before, most of the subsistence farmers live in poverty or on the edge of poverty. Their labors gain them little more than mere survival. Many of them will die prematurely because of malnutrition. Their children often are stunted mentally and physically because of the lack of a well-balanced protein diet. They have little or no access to modern medical treatment and their energies are often sapped by intestinal and blood parasites. Yet their motivations and responses do not differ greatly from those of more fortunate members of society. They are entitled to a chance to achieve more than mere survival. They deserve an opportunity to produce more, to participate more directly in the overall development of their country, and to live a more satisfactory and useful life.

Third. It is urgent to increase the production of the subsistence farmer because it is doubtful that the present commercial farming sector alone will be able to produce the food to keep pace with the current rate of population increase.

Woytinsky (1953) estimates that 40 percent of the land of the world under cultivation is in the hands of the subsistence farmer. This means that in certain areas it is much higher. For example, the Sub-Secretary of Agriculture

for East and West Pakistan recently informed me that over-all figure for his country is closer to 70 percent.

The Third World Food Survey of FAO predicts that world food supplies must be increased by one third by 1980 to merely sustain the present unsatisfactory level of diet. It is questionable whether this increase can be obtained, even with modern technological methods, on only 60 percent of the good cultivated land.

In Mexico, it is estimated that only 45 percent of the good cultivated land is farmed commercially. At its present rate of population growth the present 50 million will have grown to more than 100 million by 1990. With growing demands for corn for processing and for livestock feed this means that corn production must be more than doubled in the next 20 years, and this is not likely without raising the production of the subsistence farmers.

Fourth. Production increases are urgent to prevent a possible social upheaval. In these times, a wide disequilibrium in the level of living between one social sector and that of another is apt to cause serious consequences. It is becoming more evident each day that the rural poor do not stay out. The young men and women are migrating to the cities, or elsewhere, looking for a better way of life. Jobs are insufficient to provide work for all and the rings of poverty continue to grow around the major cities and industrial centers. This movement cannot continue without some kind of explosion. The first step in slowing down this migration is to help the subsistence farmer make more efficient use of the land at his disposal.

Fifth. It is urgent to increase the production of the subsistence farmer to facilitate rapid, orderly, and overall growth of the developing nations. An increase in output of subsistence farmers would not only provide a better life for the vast majority of people now involved in this type of activity but it also would provide a vast new market for consumer goods, thus greatly stimulating industrial development which in turn would create more jobs for more people.

Subsistence agriculture represents an enormous growth potential in most developing nations. A rapid development of this potential would stimulate a greater demand for industrial goods and a more rapid development of the overall economy. Consequently the returns could be very high. Not only can we help the individual farmer and his family to a better and more fruitful existence, we also can bring him in as a participant in the overall development of his community and his country with potential for adding to the economic stability of the whole world.

It seems apparent that no country can afford to by-pass the subsistence farmers. The question is: How can subsistence farmers with small holdings be encouraged and helped to adopt the new science-based technology?

A rapid, economic solution to this question must be found. In most countries the small farms are not going to become larger; neither is the number of small farmers going to become smaller. They are here to stay. As a matter of fact man-land ratios can be expected to worsen and small farmers are apt to become numerous as the population continues to grow.

I believe that everyone here today is aware of the seriousness of this agricultural problem. This conference is an attempt to bring together, for your information and discussion, reviews of three projects which have attempted to develop an answer appropriate to a given set of social and ecological conditions. You also will have an opportunity to see some of the activities of one of these projects. We hope everyone will enter freely into the discussions. There is much to learn and the problem is urgent. We hope that each of you will leave here with some new ideas of how you may attack this agricultural-social problem.

the puebla project: a regional program for rapidly increasing corn yields among 50,000 small holders

LEOBARDO JIMENEZ SANCHEZ [1]

TODAY I WANT to give you a general review of what the Puebla Project is about. And I want to explain *how* it has developed, rather than describe *what* the program is today. I will try to show how the people in the program have been able to overcome specific problems and what some of the accomplishments have been after three years. And I want to stimulate your thinking, because that is the first step in this approach —finding logical solutions or alternatives to the relevant problems.

You already know some of the natural characteristics of our country. Most of our rural population lives at a subsistence level, each family producing just enough for its own use. How can we make this kind of agriculture more efficient? How can the resources involved become more productive?

At the start, we must say that we don't know the answers. This is the key to our approach. We're looking for answers. We are searching, learning, looking for new alternatives. We have some strong basic beliefs — we believe in the potential of our farm sector, the maturity and scientific capabilities of our institutions and our government. We feel that new alternatives can be found by combining our resources.

So today I want to communicate to you the reasons that we believe in our approach, what we now know, and what we intend to do. And while I am detailing this progress, I hope to involve you in a discussion about the program and also learn from you some of the answers and alternatives for the future.

THE GENERAL BACKGROUND

The continuing development of Mexican agriculture is a good index of Mexico's participation in the technological revolution in recent years. In particular, this revolution has begun to focus on major needs of the rural people, a major part of the country's population.

Resources, especially arable land, are limited. The agricultural census of 1960 indicated that Mexico has about 23,817,000 hectares of tillable land. These lands constituted approximately 14.1% of the total 169,000,000 hectares registered in the census. That is to say, in 1970 the arable land would provide less than one half hectare for each inhabitant. This relationship will become more critical as population pressures increase. There is an urgent need to learn how the land resource can be made more productive.

The land limitation is accentuated by the fact that the arable land in Mexican agriculture includes 3.1% of soils with good subsoil moisture, 14.8% of irrigated land, and

[1] Professor-Researcher, Graduate College, National School of Agriculture, Chapingo, Mexico and General Coordinator of the Puebla Project.

82.1% of land with natural rainfall. These facts indicate that major attention must be given to improving the cultivation of natural rainfall areas.

From the point of view of the technician, the economist, the social scientist and the politician, these facts have fundamental implications, because about 20 million Mexican people live in these rural areas. The majority of these Mexican farmers depend mainly on cultivation of rainfed land. This may help to explain why it is of great importance to know and understand this type of agriculture.

Recent research also points up the socioeconomic polarization of our agricultural development. At one end of this spectrum are situated about 50% of the producers who generate only 4% of the total national agricultural product. On the other extreme are about 5% of the producers who generate 32% of the total national product

This polarity can be explained as a function of the resources which are available for use by the producers. In effect, 16.3% of the larger family and multifamily farms account for about 91.0% of the total value of machinery and about 97.3% of the irrigated lands. In contrast the 83.7% of subsistence and subfamily farms account for only 9% of the value of the machinery and 2.7% of the irrigated land.

In other words, 83 7% of the farm land of Mexico is operated by very small farmers or ejidatarios who operate within a rainfed type of agriculture, using traditional methods, primitive equipment, and their own capital, producing essentially for their own consumption, obtaining very low yields and participating in a very limited way in the market economy.

This situation explains why we need to increase productivity, and why we should seek ways to correct the low productivity, limited opportunities and great needs of the rural families. In number they constitute a valuable human resource for the development of the country and ought to be incorporated quickly into the economic life that is bringing so many benefits to other sectors of the population.

With these problems in mind, and feeling the great urgency of finding solutions, the Puebla Project was begun in 1967.

We have confidence in its success because of the following fundamental aspects: 1) the real concern that exists for the "problem of rural Mexico", 2) genuine interest within the public sector in seeking solutions to the problem, 3) the accomplishment of agricultural research in Mexico in finding ways to increase production, 4) the maturity of our technicians and scientists who are able to investigate the problem without dogmatic restrictions or conventions, and 5) the importance of corn cultivation within the economic and psychological aspects of the small farmer's culture.

CRITERIA FOR SELECTING THE PROJECT AREA

The concept of development embodied in the Puebla Project has continued to change as the work has progressed. For this reason it may be fruitful to synthesize what the program is, both in retrospect and looking to the future.

Fundamental Criteria in Establishing the Project

The Puebla Project was established with a central interest in learning about two essential problems which chronically affect farmers producing at a subsistence level under conditions of rainfed agriculture. The problems were: 1) low levels of production, and 2) low incomes and nutritional deficiencies. The question was: "How can we transform this vast traditional agricultural sector into a modern and viable agriculture in a short time, and, in economical terms, convert it to a practical and attractive operation?"

The Objectives

It was essential to specify the objectives in terms relevant to the problem. These objectives were: 1) to bring about rapid increases of corn yields on rainfed farms, 2) to systematize the methodology of the process of change for its possible application to other crops and in other social and economic situations, 3) to set up a program of training and preparation of technicians based on experiences gained in the solution of the problems of the small farmer within a subsistence economy.

Locating the Area

It was essential to specify the objectives ought to be sufficiently large —50,000 to 200,000 hectares— to make an effective demonstration of both the problem and the results. It should be located in an area with considerable population pressure, where corn is the principal crop. With these criteria in mind, it was decided that the project should be located in some part of the Central Plateau, an area in which about half of the population in Mexico is concentrated.

For the location of the specific area, two principal prerequisites were decided upon: 1) An ecology favorable for substantial increases in corn yields; 2) a favorable political environment for carrying out a program to stimulate

increased agricultural production. In this way, the present area was selected.

With the prerequisites specified and the area located, it was felt that the success of the plan would rest upon: 1) the appropriateness of the strategy, 2) the organization of the human elements, and 3) the capabilities, skills, and dedication of the technical personnel.

Detailed Exploration of the Area

With the area selected, a more detailed exploration was needed to obtain information about: 1) the topography and ground communications, 2) the production technology employed by the farmer, 3) the importance of corn from an economic, cultural, and psychological point of view for the farmers in the area, 4) an estimate of the yields and determination of the limiting factors in maize production, and 5) the varieties of maize used and the quantity needed for home consumption in the area. In addition, it was necessary to obtain personal knowledge about the farmers, authorities, local leaders and communities to be involved.

It also was necessary to review the agricultural development institutions, both official and private —their functions, their interrelationships, their activities in relation to the program, and their attitudes in relation to the program being initiated.

The purpose of this initial exploration consisted basically of: 1) defining the agricultural, social, economic and political problems with the aim of formulating adequate plans, and 2) determining how the program might be received by the institutionalized social environment in order to develop a successful strategy.

STRUCTURE AND ORGANIZATION

The propose structure was one that should stimulate participation of all those human elements which play a role in the process of production and distribution.

This structure would recognize that establishing human relationships among the various strata and social levels is a difficult problem in itself. The structure of social relations should permit the establishment of communication among all human elements involved in the program. Later, the concept of the Puebla Project, would move from its initial somewhat abstract stage into a more concrete image. It was accepted that the Project, although oriented toward technical aspects of production, might encounter obstacles in the area of human relations, an aspect that would have to be watched throughout the entire process.

The elements for organization of the program were divided essentially into three sectors: 1) existing agricultural service institutions, 2) the farmers of the area, and 3) the newly created technical team.

To reach the objetives of the program, it would be necessary to develop an integral focus that would allow a simultaneous attack on the multiple existing problems. This focus would permit all sectors to participate in an organized fashion, adapting their systems and

Institutional Sector	*Nature and Function*
Agencia General de Agricultura	Agricultural policy, federal level
Dirección de Agricultura del Estado	Agricultural policy, state level
Guanos y Fertilizantes de México, S. A.	Fertilizer distribution
Banco Nacional de Crédito Agrícola	Credit
Banco Nacional de Crédito Ejidal	Credit
Banco Agropecuario del Sur	Credit
Fondo de Garantía, Banco de México	Credit
Asociación de pequeños propietarios	Political organization
Liga de comunidades agrarias	Political organization
Próductora Nacional de Semillas	Improved seeds
Aseguradora Nacional Agrícola y Ganadera	Crop insurance
Compañía Nacional de Subsistencias Populares	Marketing and price support
Private commercial enterprises	Credit and investment
Agricultural Sector	
50,000 farmers in the area, potentially participants in the Plan	Producers
Technical Sector	
10-12 technicians responsible for the following programs:	
Agronomic research	Obtaining of new technology
Agricultural extension	Intense diffusion of the technology through organizing groups of farmers
Evaluation	Evaluation of social and economic changes
Coordination	Direction and application of the strategy

methods of work to the needs of the program. In this way, it would be possible to initiate the changes sought and the necessary adjustments could be made as the program progressed.

To maintain the dynamism of the process, it was considered essential to attack the problem with all existing resources, using a strategy that would permit, not only joint action, but also the participation of well-motivated personnel with the ability and interest to achieve the goals of the project. Similarly, it was necessary to have a flexible administrative system — not a bureaucratic one— an adequate budget, vehicles, and freedom of movement oriented towards maximum efficiency for the program.

THE STRATEGY EMPLOYED IN OPERATING THE PROJECT

The strategy of the Puebla Project combines resources and methods to provide a simultaneous attack on the obstacles to achieving the defined goals. It must respond quickly to new problems as they appear. This strategy must be the means by which limiting factors are overcome, according to priorities determined by their intensity and persistence.

Knowledge of Existing Conditions

The following conditions were considered as possible limiting factors in carrying out the project:

1. Cultural values in the system had persisted over many centuries. New innovations or changes introduced would need to take these cultural values into account.

2. A well defined system of farming, particularly for the production of corn, that has resisted changes from the outside. This type of cultivation is of great relevance in the economy and psychology of the farm family.

3. Chronic low yields of just over 1 ton per hectare, in spite of generally favorable ecological conditions that have permitted the producer to perceive, among other deficiencies, the low fertility of the soils. His efforts to increase yields, using inadequate quantities and types of fertilizers, have demonstrated the need to produce more; however he has been incapable of doing so with his own methods. Alternatives presented to these farmers must carry very limited economic risk if they are to be considered relevant.

4. The existence of small farmholdings on which the farmers have on the average about 2.5 hectares per family, primitive equipment, little or no capital to invest in agriculture, only 2.5 years of elementary schooling, families of five to six members, and levels of living restricted by a family income of about US$480 per year.

5. The traditional patterns of growing corn for human and animal consumption, with only a limited surplus for sale. Because of this dependency on corn for food, changes in seeds or other innovations will be considered risky.

6. The existence of service institutions for agriculture that have been established in the area for many years is at once both an excellent resource and a possible source of resistance as methods and systems of work have been defined and may be difficult to change because of the implicit risks involved. Also there is a stereotyped view that the small farmers are not good credit risks.

Restrictions and Components of the Operational Strategy

There are two restrictions that will test the efficiency of the strategy in attaining the defined goals: 1) a time factor specifying that corn yields be doubled within 5 or 6 years, and 2) a limited number of technicians (12), who must service a group of 50,000 farmers who cultivate 116,000 has in 32 municipios, and live in a very complex social, economic and cultural system.

Under these conditions, it was decided that the strategy of the Puebla Project would include the following factors.

1. Development of new technology, with the participation of the farmers in research conducted on their own lands.

2. Effective communication of agricultural information among the three participating sectors —the farmers, the directors of the agricultural institutions, and the members of the technical team.

3. Ready availability of production credit, with reasonable interest rates and a convenient time payment period, available from both official and private sources.

4. Ready availability of adequate agricultural supplies, in places which are accessible to the farmers.

5. Acceptable relationships between the costs of inputs and the prices paid for the product.

6 Convenient markets, with a guarantee price that is stable and attractive for the producer.

7. Crop insurance, with the fundamental aim of protecting the investment of the producer against climatological factors that might endanger the harvest.

Operation of the Project

The operation of the Project from its initiation up through the fourth year (1970) can be summarized as follows:

Stage I. New technology and preparation of the social system (1967-1968)

1. Formation of an adequate technical team.
2. Deve.opment of new technology obtained by research on various aspects of productivity and by development of improved seed on farmer's fields in the area.
3. Establishment of links with agricultural service institutions —federal, state and local— with a continuing flow of information about the Project which might be relevant to the functions of these institutions.
4. Contact with local leaders and farmers to inform them about the plan and to acquaint them with the ways in which yields might be improved.
5. Selection of the first 103 farmers, who applied the results of the research obtained in 1967 to 76 hectares of high yield plots in 1968. This group obtained credit, agricultural inputs, crop insurance and objective information throughout the entire season. On the average, the participants doubled their yields.
6. Detailed an extensive dissemination of the results of these field demonstrations with the participation of farmers who had sown the plots, in order to stimulate other farmers and to obtain greater interest on the part of the service institutions.
7. Greater cohesion among the technical personnel for truly coordinated work with the other two sectors involved in the process.

Stage II. High Production Program and Greater Participation (1969-1970)

At the beginning of the second phase a favorable image of the Project had already begun to form, and the permanent support of the Secretariat of Agriculture and the Government of the State of Puebla was assured. The increasing confidence in the results of the research and the day-by-day increase in the number of interested farmers, were clear indications of progress.

Although the available technology was adequate, in this phase other factors within the strategy might have become serious obstacles, especially factors such as the amount of available credit, the ease of access to fertilizers, crop insurance, etc. With the increase in the number of producers, the organization had to be modified because it was impractical to work with each producer individually. For this reason, farmers were encouraged to organize into groups in accord with their own rules.

It seemed that all possible obstacles had been anticipated, but a severe drought in 1969 limited the expansion of the Project. The 1970 cycle also began with a prolonged drought of about two months that threatened to put brakes on the project's expansion, especially due to restrictions of credit.

Luckily the rains began in earnest in June and it now appears that 1970 should be one of the best crop years since the beginning of the Project. These conditions should contribute substantially to increase yields for participating farmers who follow the recommendations for high production, and will generate interest among a greater number of farmers who way want to take part in the future.

EFFECTS ON THE SOCIAL AND ECONOMIC SYSTEM

The success of the strategy has been very encouraging for the participants. Evidence of this success is shown in Tables 1, 2 and 3.

TABLE 1. Operational Progress of the Puebla Project, 1967-1970.

	1967	1968	1969	1970
Participating farmers	30	103	2,561	4,833
Groups organized	—	—	128	218
Area (hectares)	—	76	5,838	12,496

TABLE 2. Social Impact of the Project, 1967-1970.

	1967	1968	1969	1970
Families benefited *	—	103	2,561	4,833
Inhabitants benefited	—	566	16,500	26,585
Reaction of the farmers	host.	skep.	interest	enthus.
Reaction of the institutions	—	skep.	interest	interest

TABLE 3. Economic Impact of the Project, 1968-1970.

	1968	1969	1970
Credit provided (US$)	226,617	447,713	787,665
Harvest of participants (tons)	304	17,514	—
Value of harvest (US$)	22,861	1,317,453	—
Recuperation of credit (%)	100	96	—

Progress at the Operational Level

The number of participating farmers has grown rapidly. Agricultural research was initiated in 1967 with 30 farmers. The results were extended to 103 farmers with small but

commercial scale plantings in 1968. This number increased to 2,561 in 1969 and 4,833 in 1970.

The land area devoted to high yield plantings grew from 76 hectares in 1968, to 5,838 hectares in 1969, and to 12,496 in 1970. The response of the farmers has exceeded all expectations, considering the relatively short period of years and the damage from the severe drought in 1969 and again in early 1970.

It is clear that the farmer will always be fearful of the risks caused by variable rainfall and that this will influence his decisions, as well as the decisions of the credit institutions. The quality of the research findings, and their skillful application, have generated increased confidence in contending with risks caused by controllable causes.

Social Impact

The true significance of progress should be measured in terms of the farmer's family. In 1968, only 103 families obtained a direct benefit in the form of yield increases. In 1968 this benefit had been extended to 2,561 families, while in 1970 the number of families reached was 4,833. In terms of total number of family members, the number is 5.5 times greater. Although these results are significant, a considerable task remains. Nevertheless, a more rapid expansion may be expected because of the favorable change of attitude of the farmers. The hostility and skepticism of 1968, have been transformed into interest and enthusiasm on the part of those participating. The help provided in 1970 by the public institutions and the private development agencies represents a major encouragement.

Economic Impact

The farmer using his traditional agricultural system had obtained, on the average, a net gain of less than US$27.35 per hectare.

The farmers who entered the Project were able to increase their net gain to $125.96/ha. In other words, those who continue to grow their crops with traditional methods are passing up approximately $98.61/ha.

Other indicators of the economic impact would include the volume of credit granted In 1968 only the equivalent of US$226,617 dollars was loaned. This was increased to 447,713 dollars in 1969 and to 787,665 dollars in 1970. These amounts have been granted by the official banks —Ejidal, Agrícola and Agropecuario del Sur— and a substantial amount was loaned by the private institution "Impulsora de Puebla, S. A.". These institutions have been able to provide the recommended quantities and types of fertilizers with the assistance of the national fertilizer company "Guanos y Fertilizantes de México, S. A."

The response of the farmers in repaying their loans has been very favorable. Of the credit granted by private enterprises in 1968, 100% was recuperated and of that granted in 1969, more than 96% has been repaid. These results, under the difficult conditions of rainfed agriculture, provide strong evidence of the moral strength and feeling of responsibility on the part of the majority of the participating farmers. There seems to be little doubt that the excellent credit recovery will continue in the present season. There now is an educational program to make the farmers aware of credit opportunities and at the same time to encourage timely repayment of the loans.

FINAL CONSIDERATIONS

The results show that it is feasible to obtain substantial increases in corn yields. For the farmers these increases have begun to create a new confidence in their capacity to produce. Once involved in these technological changes, the farmers now feel that they will be able to produce more corn per hectare, and they have begun to try other things. Many would like to produce the maximum possible amount of grain in order to sell it and use the income for investment in simple equipment for planting and fertilizing, in work animals, and in animals for milk and meat production. Others have decided to improve their homes, and to buy a television and other modern appliances. Still others have decided to reduce the area devoted to corn and use this land for other crops such as beans and fruit. Still others have started small family-run swine operations, using the excess corn for feed after satisfying their own food needs.

With the experience gained up to now, it can be assumed that expansion of the program will increase the benefits to the area. For example, considering that it is possible to cultivate 90,000 hectares of corn in the region, if average yields are eventually raised from 1300 kg/ha in 1967 to 4 metric tons per hectare (62 bushels per acre), the increased production would provide the farmers of the region with an increased crop value estimated at 17.5 million dollars each year. This quantity is important not only for its size, but because a large part of this money will be reinvested in agriculture and devoted to bettering the

family living condit[illegible] [illegible]r may be incorporated more [illegible]ly in the economy of Mexico, boosting his power to buy both production inputs and consumer goods.

Looking at this in even broader perspective, the results obtained in Puebla suggest possibilities for increasing the productivity of another 6 million hectares now under subsistence production in other ecological favorable areas of Mexico. Direct benefits could be carried to a great number of families and perhaps, most important, over the long term, a firm step could be taken to extend the technological revolution to the small farmer and the ejidatario. The application of these experiences in other areas will be possible through the program of professional training within the Project. This year a new technical team will be formed for Mexico and another for Colombia.

The experiences of the Puebla Project show that the capacity, interest and imagination of politicians, administrators, technicians and scientists can be successfully applied to the challenges and opportunities of this important social and economic problem.

discussion

PAN. What are the rates of interest for the Puebla Project farmer? What for private and what for public sources?

JIMENEZ. Public is 9% a year. Private is 18%, one and a half per month. This has been authorized by Government. It is an acceptable rate of interest.

WILLIAMS. Who buys the corn in the area?

JIMENEZ. There is a governmental institution, CONASUPO, but we do not force the farmer to sell to CONASUPO. Last year there was a severe drought in the area and the farmers who had corn to sell were able to market it 3 or 4 months after harvest at prices well above that paid by CONASUPO at harvest time. CONASUPO paid about $940 pesos per ton, and the price in the market rose to about $1,400 per ton.

MOSHER. What was the total production of these farmers? Do you have the figures?

JIMENEZ. We will provide these figures in presenting the evaluation program. Ing. Heliodoro Díaz will provide these data this afternoon.

MACKENZIE. What is the marketing system? How do they sell corn? Are there any kinds of cooperatives?

JIMENEZ. We have initiated a kind of organization that so far has no name. We expect that this organization will play a definite function in marketing. This organization is a result of people dealing with common problems. At present, the general rule is that each farmer and his family decides when, where, to whom and how much they sell.

PAN. What is the ratio of technical staff to farmers?

JIMENEZ. We started the program with one man in soils and one in corn in 1967. There were about 30 farmers cooperating to develop a new technology. In late 1967, we included the coordinator of the program. In 1968 we added a man in evaluation and one in extension. In 1969 we added additional personnel and now have about 13 technical staff working with about 5,000 farmers. Eventually, we expect to reach up to 40-50,000 farmers with little further expansion in staff.

MACKENZIE. Do they work along with local technicians? Is there a State Department of Agriculture here in Puebla?

JIMENEZ. Yes, there were two part-time extension agents in the area. However, for the Puebla Project technical team, new young people were selected, in most cases technicians just coming out of the schools of agriculture. There is a department of agriculture called Dirección de Agricultura in the State of Puebla.

STEPPLER. Who had to identify the key people having interest in your program when the program was initiated, say the first and the second years? Who were the key people in the districts to get the program working?

JIMENEZ. Well, first of all, the key people to identify were those in the communities included in the working area of the project. The technicians in the team with social sciences background were the ones in charge of identifying the social structure of the communities. Afterwards, they identified the key people in these areas through a selection process. By the way, in these areas, key people were not, in most cases, the formal leaders, but others who seemed to be enthusiastic with the program and outstanding in the community. The initial task in this process, was informing farmers about the program and giving them some ideas as to how the farmers could participate, and what the requisites would be for participating. The requisites were that they should be farmers with an honest desire to increase production and with a high sense of social responsibility. Throughout this process, people were deciding, voluntarily, when to join the project.

BYRNES. My question relates to the first objective —to increase the production of maize. Is this the objective —increase production of maize— or is the increase in maize yields a means to attain other objectives?

JIMENEZ. Objectives are stated in a simple form so people understand them. In this case, to increase production is just a means. A means for what? There are several alternatives. I would say this: if you see what farmers are doing at present, you'll see that they are making many decisions in order to increase production as much as possible. There is an immediate need. At the state level, there is a deficit of about 100,000 tons of corn a year and the project area represents a potential to satisfy present needs, both for participants in the project and people in other areas of the state. Then the proposed objective of increasing corn production seems to be relevant to farmers and feasible for the project. However, reaching this objective will lead to other related goals. In this context increased production of corn may make necessary other decisions, for example: should corn acreage be reduced and other crops substituted? Others may decide to continue planting the same number of acres but use the corn to produce milk, eggs, pork or something else. Others may produce as much corn as possible to sell it on the market. There is much to be learned from this type of process.

HUBERMAN. You talked, Dr. Jiménez, about the families and the heads of the families. My question deals with the process of making decisions. What is the role of the woman in each of these families? You are convincing them, and working on that?

JIMENEZ. Well, I think the justification for not including all the information in the presentation is to stimulate some questions. This is a very good question. I have mentioned that there was some hostility at the beginning of the project. This hostility came mainly from women. To try to understand the woman's role in the decision making process, let us examine some examples. Farmers had decided to participate in the program and take fertilizers and other inputs, on credit, but because of the wife's opinion, they decided later on to reject the initial idea of accepting credit. The wife said "you better do not get into the program because you will be indebted", and so on. And this is right, for these people are not experienced nor commercially oriented; they have just started to reach a level beyond that of subsistence, and women see the risk not for the farm enterprise but for the family itself. Another role of the woman is the administration of the product and the house as a whole. Based on these and other facts, it would be convenient to present all agricultural information not just to the men, but also the women and children in the rural areas. All of them are part of the farm working system that has operated for years. When new procedures come from outside, they tend to break up the existing system and people tend to look for stability or new forces of equilibrium. Defensive attitudes arise and women take a large part in this. I suspect that this can be reduced through effective communication and demonstration of new advantages to the women as well as the men.

ALVAREZ. I am sure that many new questions have been stimulated, and that Dr. Jiménez will be happy to discuss his ideas and experiences with you personally in more detail. I am afraid that we do not have time for more questions now.

rapid increases in corn yields on small irrigated holdings in the region near chapingo, mexico

ABDO MAGDUB M.[1]
ALBERTO ZULOAGA A.[2]

THE CENTRAL THEME of our meeting deals with the methods of achieving rapid increases in corn yields on small farms under favorable environmental conditions.

Let us first clarify what we mean by "small farms" and "favorable environmental conditions" for the production of corn.

The term "small farm" is difficult to define. In Mexico, for census purposes, a very rough classification has been adopted: smaller farms of less than five hectares (12.5 acres) and larger farms of more than five hectares. To be consistent with this criteria, we are considering as "small farms" those having 5 hectares or less. In Mexico, as a whole, this category included 1,596,879 units at the time of the 1960 Agricultural Census, with 241,766 of these farms located in the irrigation districts and covering a total area of about 560,000 hectares.

With respect to the "favorable environmental conditions" for corn cultivation, we refer basically to temperatures and rainfall that favor good development of the plants, and a high grain yield.

The latest statistics from the Bureau of Irrigation Districts show that in Mexico as a whole about 400,000 hectares of irrigated land were planted to corn in the 1968-1969 season. The average yield on this irrigated acreage was in the neighborhood of 2,500 kg/ha (about 38.5 bushels per acre). Considering the favorable production conditions available under irrigation, this yield is very low It is far from what might be achieved with the application of the available technological information. For example, the latest statistics show that only one-half of the acreage devoted to irrigated corn is fertilized.

In the present paper we will present our experiences during four years of work in an area where rainfall is frequently not adequate for good crop production, but where supplemental irrigation is available. The area is located inside a so-called "critical agrarian zone", characterized by heavy population pressure on the land and low levels of income. Because of this, we feel sure that our experience will find rapid acceptance by other farmers. Similarly, we are hopeful of support by the institutional services which form the agricultural infrastructure in those regions where farm activity represents the main source of income for the producer, and where physical and ecological conditions are favorable for crop production.

Antecedents of the High Yield Program

The National School of Agriculture began functioning at Chapingo in 1923. In addition to its main purpose of preparing agronomists, it has been able to give technical assistance to

[1] Head of the Small Farmer Program of the National Productivity Center, Mexico.
[2] In charge of the Agricultural Promotion and Extension Department, National School of Agriculture, Chapingo, Mexico.

its rural neighbors. Such assistance has been provided ever since the establishment of the school at its Chapingo location, but only in the last decade has there been a well designed program.

With the creation of the Agricultural Promotion and Extension Department of the National School of Agriculture in 1960, the first firm steps were taken to extend the benefits of new farm production techniques to farmers of the area. This action program also provided a demonstration area for student training, where they could learn at first hand the methods that farmers were using and then propose improvements.

The first systematic technical assistance for farmers in the area around the School of Agriculture (ENA) was initiated in 1966 and it is this program that is described here. The first step in the new program was to define a work area. Twelve municipios were chosen with about 30,000 hectares under cultivation. Of this area, about 6,000 hectares have water for irrigation purposes and the rest depend exclusively on rainfall.

It was decided that at the beginning major attention should be focused on the 2,500 hectares of irrigated corn which are planted each year. Corn was selected because it is the most important crop in the area and good technical information is available in the region as a result of the research work done by INIA at the El Horno experimental station.

Description of the Area

The program area consists of 12 municipios in the State of Mexico —Acolman, Atenco. Chiautla, Chiconcuac, Chicoloapan, Chimalhuacan, Ecatepec, Los Reyes La Paz, Papalotla, Tepetlaoxtoc, Texcoco and Tezoyuca.

1. Geographical Factors

Location. The working area is located at 98° 53' west longitude and 19° 34' north latitude. It is situated in the eastern portion of the State of Mexico and is bounded on the north by the municipio of San Juan Teotihuacan of the same State of Mexico, to the east by the States of Puebla and Tlaxcala, to the south by the municipios of Ixtapaluca and Chalco of the State of Mexico, and to the west by the Federal District.

Altitude. The area is located at an average altitude of 2,321 meters above sea level, with a minimum of 2,240 meters and a maximum 3,000 meters.

Acreage. It includes an agricultural area of 63,125 hectares, of which only 30,607 are adequate for productive purposes —179 hectares for fruit trees and agaves; 18,815 ha for pastures and grassland; 9,016 ha for forests; and 4,508 ha of non-productive lands, heavily eroded.

Topography. The region can be divided into three well defined zones: 1) a level part with slopes of less than 5%, varying from 2,240 meters at the shores of Lake Texcoco to a level of about 2,275 meters; 2) a hilly portion, with slopes from 5 to 15%, broken by a number of gullies and ravines; and 3) a part of the Sierra, from the level curve of 2,400 meters to the upper limits of the watershed. In this last portion we find high altitudes including the mountains of Telapon and Tlaloc, Teconal, Texcutzingo, Santa Catarina, Cuepango, Tezahitl, Huepango and Topepa.

Climate. The climate of the area is considered semi-dry with dry winter, temperate, with a well defined winter season and its symbols are: DiB_2 'a'*. The climate is also considered temperate, moderately rainy, with mean temperatures of 3 to 18 °C in the coldest month, with dry winter, not too severe, and sporadic rains**.

The extreme temperatures are 6°C in February and 34°C in April. The frosts usually begin in October and end by January, though some frosts have been recorded in April. From April to September, it is common to have hail storms; but without serious consequences***.

The average yearly rainfall amounts to 640 mm, most of it in a period of 96 days. The highest yearly rainfall occurred in 1941 with 1,040 mm, and the lowest was registered in 1936 with only 416 mm. The maximum average monthly precipitation occurs in July, and the minimum during January. The rainy season begins in June and ends in September.

Water resources. The area under consideration comprises an extensive hydrographic system which flows from east to west. Among the main streams are the rivers: Papalotla, Chiautla, Magdalena, Texcoco, Huexotla, San Bernardino, Santa Mónica, Chicoloapan and Coatepec. All of them are of a torrential nature, have their resources in the Rio Frio Sierra and flow into Lake Texcoco.

The annual runoff of these streams is 47 million cubic meters, not taking into consid-

---

* Alfonso Contreras Arias. Régimen de Heladas en la Región de Chapingo.

** David Llerena, Professional Thesis. Escuela Nacional de Agricultura, Chapingo, México.

*** Weather Station. Escuela Nacional de Agricultura. Chapingo, México.

eration the water held at the upper part of the Sierras nor that stored in ponds and small dams and then used for irrigation*.

There are also more than 100 deep wells in the area, of which approximately 50% are not functioning now, but might be put back into service as an important source of irrigation water.

2. Socio-Economic Factors

Demography. In this region live 212,773 inhabitants, belonging to 36,330 families with an average of 5.7 members each. The population density is 150 persons per square kilometer. The economically active population is estimated at 29.6% of the total figure, or 63,000 persons, of which 56% are occupied in farm activities (1960 census).

Income. The main sources of income of the rural population in this area are self-employment in agriculture and animal husbandry, day labor, small commerce, and some trades. Agriculture, in spite of the large number of people engaged in it, produces very little cash income. Cash income comes principally from other activities, especially salaried labor. During 1965, the average cash income per family and per year, was about US$1,440. However this average does not fully indicate the distribution of real income as there are families with cash incomes of less than $250 per month, resulting in daily incomes of less than $US.64 for six persons.

Land Tenure. There are two main types of land tenure in the area: private and ejidal. About 48% of the land is held in private property, 51% in the ejidal system, and only 1 percent in other types of tenency, mainly communal lands.

Although various authors have indicated that the ejidal system may be an obstacle to economic development, because it hinders capital investment and therefore limits the improvement of productivity levels, in our case ejidal ownership does not have this characteristic. In this case the farmers in the region consider the land they work as theirs whether it is held under ejido or private tenure.

Agrarian Structure. Land distribution among families is uneven. Among the ejidos, the size of family holding goes from 0.5 hectares in the case of the ejidos of Santa María Chimalhuacán and Santa Catarina, to as much as 7.0 hectares in the case of San Pedro Cuautzingo. Under private ownership, the size of holding goes from 0.5 hectares up to 400 hectares per owner, including a wide range of sizes between the extremes.

The small size of plot, both ejidal and private, which is the typical situation in the area, is a serious obstacle to improving production and levels of living among the farmers. The small parcels in some cases reduce the chances of a significant increase in family income from farming and force the farmers to keep agriculture as a secondary activity, or to abandon it completely in order to work full time at other activities Those who have very small parcels or no land at all to cultivate, become seasonal farm laborers at US$1.20 to 1.60 per day except for those cases where they acquire a higher level of education and better paid employment in some other activity. The under-employed and those without employment are now a limiting factor to the economic development of the area. The majority of the families with one or two hectares will have serious difficulties in improving their levels of living, if they must depend exclusively on agricultural activities.

3. Service Infra-structure

Many public and private institutions already exist in the area, and their coordinated participation could help greatly in the economic development of the rural population.

Research and Technical Assistance. Among the institutions that perform some activities related to this field in the area covered by the High Yields Program, are the following: The National School of Agriculture and its Graduate College, the National Institute for Agricultural Research (INIA), the National Extension Service, the Bureau of Plant Sanitation, the Basic Research Center of INIA, the International Maize and Wheat Improvement Center, the Secretariat of Water Resources, the Forestry Unit at San Rafael, the Directorate of Agriculture of the State of Mexico, the Coordinated Services of the Ministry of Health, the Directorate of Community Development and the Secretariat of Public Education, and the Small Holders Program of the National Productivity Center.

The following institutions provide credit to farmers in the area: The Ejido Bank, the Agricultural Bank, the Agricultural and Livestock Credit Bank, the National Bank of Mexico, the International Bank, and the Guarantee Fund for Agriculture, Livestock and Poultry.

Commercial Sector. For the distribution of inputs and the marketing of the agricultural products, the following operate in the area: fertilizer dealers of Guanos y Fertilizantes de

* Roberto Rodríguez L. Professional Thesis. Escuela Nacional de Agricultura. Chapingo, México.

Mexico, the National Seed Producer, distributors of agricultural tools and machinery, distrib utors of insecticides, weed killers, fungicides, veterinary products and livestock feeds, and representatives of the price control agency, CONASUPO (Compañía Nacional de Subsistencias Populares).

Formal Organizations. There are several formal organizations of farmers, including: the Milk Producer's Association, the Regional Association of Hog Growers and Milk Producers, the Regional Association of Poultrymen, the Ejido Livestock Producers Association, and local boards for the management of potable water and irrigation.

Formal Education. As a rule, in each town there is an adequate building devoted to primary education, but there is a serious lack of teachers and the education given is far from complete. Only 6 percent of the rural schools in the area give a full 6 year program while in the rest the education stops at the 3rd or 4th grade. The illiteracy rate among the population of 7 years or more is 26 percent.

Communications and Transportation. There are three paved roads in the area: 1) Mexico City-Texcoco-Veracruz; 2) Mexico City-Ecatepec-Texcoco, and 3) Venta de Carpio-Archaeological Zone of Teotihuacán. These roads are used mainly for transit from Veracruz and Tlaxcala to Mexico City, from Pachuca to Mexico City, and for the tourists who visit the archaeological zone of San Juan Teotihuacán.

The rural roads, except the one that connects Tepetlaoxtoc, and Resurección and San Vicente Chicoloapan with the highway Mexico City-Veracruz; and the one that connects San Miguel Chiconcuac with the highway Mexico City-Ecatepec-Texcoco, are of dirt and in bad condition, but generally passable the year around.

The difficulties of travel and of moving merchandise from the urban centers to the rural areas, tend to limit the availability of agricultural inputs in the area, and this is an important obstacle to increasing agricultural productivity.

Price Policy. The lack of price support for most farm products, with resulting low and variable prices, combined with high and increasing prices for the agricultural inputs, results in easy exploitation of rural labor by commercial interests. The lack of capital among these farmers also tends to limit the acquisition of the agricultural inputs that are recommendable from a technical point of view, thereby, acting as a restraint on the economic development of the area.

4. Personal Factors

Among the personal characteristics of the farmers that may influence the realization of a High Yield Program, we can mention: attitude towards the change, traditionalism, level of aspirations, orientation towards risk, and level of preparation. Here we will deal with only one of these —level of preparation.

Preparation. This factor has occupied the attention of most institutions and persons that have wanted for any reason, to stimulate increased agricultural production. In the area around Chapingo, technical assistance was started in an organized form during 1960 and has been carried out, until recently, through an agricultural extension service that has recommended improved materials —not yet used or improperly applied— such as fertilizers, seeds, weed killers and insecticides. The extension service also has recommended new techniques and procedures for animal production, organized short courses for producers, made field demonstrations, and, in several ways attempted to prepare the farmer to apply better systems of organization and thereby develop a commercial agriculture. However, it has been found that this kind of extension program is not enough. What it is needed, in addition, is to change at least in part the physical and social factors of production so that producers may use their full capabilities in utilization of the available resources and fulfillment of their needs.

Strategy

The previous paragraphs have provided a general picture of the working area, outlining some of the problems which must be solved in the economic development of regional agriculture.

To accomplish this development, the Promotion and Extension Department of the National School of Agriculture started a "High Yield Program for Irrigated Corn", with the objective of establishing a strategy and a methodology that could be applied later to other types of programs and in other regions of the country.

There are two points that were considered fundamental in the strategy followed in the Chapingo area.

The first was the elimination of the demonstration plot in its traditional sense as a method to transmit technical assistance to farmers. Traditionally, extension programs have established small demonstration plots for which all of the material has been provided by the technicians. In this case, it was decided at the outset that the demonstration area on each farm would be all of the acreage devoted by a producer to raising a commercial crop. It was assumed that the farmers of the region had already seen the advantages of using improved seed and fertilizers, because of their proximity to the experimental fields and to highly productive dairy farms as well as to the National School of Agriculture located at the geographical center of the area. It seemed that a new approach and a change of strategy was needed for these programs of technical assistance.

The second important decision in the operation of the high yield program, was to charge the farmers, on a credit basis, for all materials provided. This included seeds, fertilizers, weed killers, insecticides —all of the inputs which required an out-of-pocket expenditure that the farmers were not able to cover.

The High Yield Program in 1967

In 1967 the program was initiated at an experimental level, in eleven communities with a total of 23 farmers and 29 hectares. To this end the producers received a credit of about US$1,600 from the Banco Nacional Agropecuario.

When this program began, the technical staff of the Agricultural Promotion and Extension Department included a department head and three agronomists with different levels of professional experience, but with a common denominator: youth and a great enthusiam for their work.

The results of the first year suggested great possibilities for the program. The plantings were called "high yield plots" and they were used for demonstrations. In those communities where more than one field was established, the impact was stronger, due to the fact that the members of the community were exposed at several points to plantings that stood out from neighboring ones as examples of improved production.

During the first year of activities, the agronomists gave individual attention to the participating farmers. The final results were highly promising and provided experience to be used later in planning future strategy.

The statistics for the first year were as follows:

Participating communities	11
Participating farmers	23
Area planted under program	27.25 ha
Average yield per hectare	9,025 kg/ha
Total production of grain	245.9 tons
Total costs of production	US$ 6,768.96
Total value of the crop	19,833.76
Net profit	13,064 80
Net profit per hectare	479.44
Credit granted	1,616.80
Repayment of credit	100%

A key aspect of the strategy was that related to the distribution of inputs and loans. During 1967, because of the small number of participants and the small acreage included in the program, the distribution of inputs was made directly to the farmers at the proper time.

The needed materials were delivered in two stages First each farmer received the seed, part of the fertilizer and the weed killer. Later he received the rest of the fertilizer. The farmer signed an informal receipt for the materials used and the credit documents were legalized later.

It is important to note that this method of lending does not follow the rigid tradition observed by the credit institutions. In initiating a new procedure, the high yield program was experimenting with simplified ways of providing credit directly to producers. To sign the final loan papers, a meeting was held at Chapingo, where a detailed explanation was given to the farmers in relation to the amount of the credit. By that time the corn crop had already had its last cultivation and from then on the only care necessary was to watch the soil moisture in order to apply irrigation in case rainfall was inadequate. The agronomists visited the plots frequently and found the farmers enthusiastic with the development of their crops.

In order to attain full repayment of the loans, a letter was sent to each farmer as soon as field estimates were made of the probable harvest, informing him about the amount due to the bank, the date of maturity of the note, that it could be paid at the program office at Chapingo and that prompt repayment would avoid additional interest charges. The total loan was repaid in each case well in advance of the due date.

With the experience gained in 1967, a new strategy was prepared for 1968 in order to reach more farmers and expand the acreage under the high yield program

Activities During 1968

The 1968 activities were started in February with a review of the technical information needed for making recommendations to farmers. This information was needed in order to anticipate the need for inputs, especially seed and fertilizers and to estimate credit needs. A meeting was held with the specialists from the National Agricultural Research Institute (INIA), the Graduate College of Chapingo, and the National School of Agriculture (ENA).

From this meeting, the following recommendations were adopted: for early April plantings the hybrid H-129 should be used and for late April and early May plantings, the hybrid H-28.

The fertilization plan include 50 kg of N rigated, well-fertilized plantings at this altitude was 60,000 plants per hectare, requiring 20 to 22 kilograms of seed.

The fertilization plan include 50 kg of N and 50 kg of P_2O_5 to be applied at planting time and 70 kg of N for the second application 30 to 45 days later. It was recommended that this second application be made just prior to a cultivation and that an irrigation be given immediately afterwards. A pre-emergence herbicide was recommended to eliminate weed competition during the early stages of the growth —preferably one kilogram of Atrazine per hectare banded over the row.

The application of a soil insecticide was also recommended —10 kg/ha of granulated Aldrin at 20%— based on experience with insect problems in several of the communities where the program operated in 1967.

Once the recommendations were defined, an estimate was made of the credit needed to cover 250 hectares during 1968, and an application was presented to the Banco Nacional Agropecuario in order to buy all of the materials well in advance.

Simultaneously, the recommendations were printed in bulletin form and other extension materials were prepared for promoting the program in the selected communities, in order to interest additional farmers in participating.

Discussions were continued with four organizations to obtain the necessary materials for 1968: 1) with the Banco Nacional Agropecuario, to be sure of credit to buy the inputs for the program; 2) with Guanos y Fertilizantes de México, in order to obtain on time the needed fertilizers; 3) with the Productora Nacional de Semillas, to assure the proper amount of the required seeds; and 4) with a private concern to obtain the herbicides and the insecticides.

The estimated quantities of materials for 1968 were:

50 tons of the formula 25-25-0
90 tons of ammonium sulphate
6.5 tons of hybrid seed
100 kg of Atrazine, and
500 kg of granulated Aldrin at 20%

Warehouse space was prepared at the National School of Agriculture at Chapingo to store these.

After the plan had been approved by the collaborating institutions, the next step was to interest the farmers of the communities selected to participate in the 1968 program. The criterion applied in choosing the communities was that they have water available for supplemental irrigation during critical periods when the rainfall would be inadequate. On this basis, 29 communities were selected.

Then a calendar of activities was formulated for the month of March, promotion was started, and the list of participant farmers drawn up.

As a first step in the promotion, letters were sent to the municipal and ejido authorities in each community, requesting their collaboration. The participation of these officials was vital as they would know what times and places were most indicated for meetings with the farmers.

In 1968 only one visit was necessary to each community and an audio-visual mobile unit was very helpful for the purpose. As a key part of the promotion, farmers were told that by participating in the program they would have available the credit that had been arranged with the Banco Nacional Agropecuario. The only requisites to be satisfied for participation were: that their land be of good quality, that they have facilities for supplemental irrigation, and that they follow the technical recommendations for corn production. It is worth noting that in this case the bank was willing to disregard the credit history of the new clients in approving loans. It was well known that the majority of the farmers in the Texcoco area, especially the ejidatarios, had old debts.

In 1968 it still was possible to give personal technical assistance to the participants; however, the problems of handling and distributing a major volume of materials became obvious. In most cases, the technicians took the supplies to the farm, but it became evident that a change in method of distribution would be needed if there was to be an increase in

area covered and in number of participants. As a result, farmers were later asked to pick up their materials at the office of the program, thus achieving a closer contact between farmers and the institution. The procedure, established in 1967, of having the farmers come to the offices of the program to sign their credit documents, was continued.

A summing up of the 1968 program, shows the following results:

Participating communities	29
Participating farmers	155
Acreage in the program	241 ha
Total production of grain	1,493 tons
Production of grain per ha	6.2 tons
Value of production	US$124,987.60
Cost of production	51,630.52
Total net profit	73,357.17
Profit per hectare	303.97
Credit granted	15,231.09

The last amount represents about ten times more than the credit used the previous year, and 99 percent of the loans were repaid

In 1968, a new technology for grain storage was introduced to help farmers take care of the production increase. This consisted of the construction of "family granaries" capable of storing corn on the cob with 25 to 30 percent moisture. This practice allowed the farmer to start the harvest one month earlier than usual and thereby vacate the plot for a winter crop.

As a result of this promotion, five family granaries were constructed in five different communities as demonstrations of the advantages offered by this type of storage.

The 1969 Program

For 1969, the third year of the High Yield Program, it was possible to move ahead more confidently based on the experience of two previous years. In planning the technical program, recommendations of the research institutions were again taken into account.

The promotion work was improved, above all in the preparation of audio-visual aids, using specific examples of previous experiences with the farmers. A schedule was prepared for the promotion work in the communities chosen to participate. Three projectors, an audio-visual mobile unit, and a station wagon equipped with loudspeakers were obtained for use in the area.

The most important changes introduced in 1969 were:. 1) an attempt to organize groups to make it possible to reach a greater number of participants without increasing the number of agronomists, and 2) a system for distributing fertilizer, seed and other inputs so as to quickly distribute the increased volume.

To handle this distribution, the following procedure was initiated. Based on a schedule of deliveries, the commercial distributor accepted responsibility for placing the fertilizer in the participating communities, in accordance with the recommendations of the program. The Banco Agropecuario paid for the material delivered. The same procedure was used for distributing improved seeds with the program office at Chapingo serving as the distribution point.

Using this procedure, enough fertilizer was delivered in 1969 to cover requirements for 450 hectares. The problems and experiences of 1969 will serve to improve the distribution system in the future, when it is hoped to have farmers' groups participating in every community.

The final results of the operations during 1969 were:

Participating communities	24
Participating farmers	291
Acreage covered	455 ha
Grain production per ha	6 tons
Total production of grain	2,700 tons
Total costs of production	US$ 95,580.00
Total value of production	226,800.00
Total net profit	131,220.00
Net profit per ha	291 60
Total credit granted	22,739.60
Repayment of credit (through July, 1970)	93%

From the previous figures we can see that the value of production is ten times the amount of the credit and the net profit is high although the number of participants remained small.

The 1970 Program

In 1970 the Small Holders Program of the National Productivity Center became one of the participating institutions in the High Yield Program. The main interest of the Small Holders Program is extending the techniques of farm management and promoting better systems of organization in rural communities. Its goal is greater efficiency in the use of the services and resources devoted to increasing rural productivity.

The promotion activities improved again and were handled more efficiently in 1970. To encourage the formation of groups two meetings were held in each community. For the first meeting a letter-invitation was sent to each of the farmers who had participated during the previous years, suggesting that they invite other persons who might be interested in joining the program. In this first meeting, the re-

sults obtained in 1969 were presented and the farmers were urged to strengthen their group organization and expand the impact of the program.

During the second meeting, the responsibilities of the representatives, and those of the members of the group were explained. At the same time members were informed of the conditions of the loans, the help and materials they would receive, and the responsibilities they accepted by participating in the program.

The same system of distributing materials has been maintained, but the complications continue to increase as more acreage and more participants become involved. Some representatives of groups now function as local distributors, making the operations easier.

Based on this experience, we have concluded that the most efficient form for distributing fertilizers is (1) to have the farmers, through their groups, pick up the fertilizers at the distribution point, or (2) establish several local centers for delivery of the merchandise.

It is evident that the system for distributing inputs, especially those that are difficult to transport, is one of the crucial problems that needs to be solved if small farmers, already established in communities far from the commercial centers, are to benefit from the new technology.

The results for 1970, up to July, are the following:

Participating communities	36
Participating farmers	418
Acreage covered	593.25 ha
Credit granted	US$31,916.71

Taking into account the results from the three previous years of activity, for 1970 an average yield of 6 tons/ha is expected. With this estimate, the following results are expected:

Total production	3,559.5 tons
Total value of production	US$298,998.00
Total costs of production	126,006.30
Total net profit	172,991.70
Net profit per ha	291.60

SUMMARY OF THE YEARS 1968-1970

A detailed analysis of results obtained during the past three years of activities, allows us to make the following summary:

	1968	1970
Number of communities participating	29	36
Participating farmers	155	418
Acreage covered	241 ha	593 ha
Average yield of grain	6.2 tons	6 tons*
Total production of grain	1,493 tons	2,700 tons*
Total value of production	$124,987	$226,800*
Total cost of production	$ 51,630	$ 95,580*
Total net profit	$ 73,357	$131,220*
Net profit per hectare	$ 304	$ 291
Amount of credit granted	$ 15,231	$ 31,917
Cost of the technical assistance	$ 5,880	$ 8,280
Cost of the technical assistance per hectare	$ 24	$ 14
Cost per participating farmer	$ 38	$ 20

* Figures for 1969.

With the results obtained up to now, we can conclude that the establishment of a strategy which includes: (1) systematic technical assistance, and (2) an organizational system for the farmers to encourage greater use of the already established service infrastructure, can lead to (3) substantial increases in production on those land having adequate water resources, and thereby (4) generate much higher income for the farmers.

the program of the foundation for promotion of cooperatives (fpc) in el salvador

JOSE ROMEO MAEDA
JESUS MERINO ARGUETA
SEBALD G. MANGER-CATS [1]

EL SALVADOR IS the smallest country in the Americas, and the most densely populated, with nearly 300 people per square mile. The population totals close to three and one-half million in a territory of 21,000 square kilometers. The country is largely agricultural, with 62% of its population engaged in agriculture and livestock production. The agricultural sector contributes 30% of the national product and 60% of the country's exports. Corn occupies about 200,000 hectares each year, most of it planted in the "first" planting in May (Table 1).

TABLE 1. Corn plantings in El Salvador, by season and by zone, 1967-68.

	Area (ha)	Production (ton)	Yield (kg/ha)
PLANTING			
First	175,736	231,851	1,319
Second	17,973	18,033	1,003
Third	5,991	7,729	1,290
Totals	199,700	257,613	1,290
ZONE			
Western	31,952	43,794	1,371
Central	93,859	131,382	1,399
Eastern	73,889	82,436	1,116
Totals	199,700	257,613	1,290

SOURCE: GAFICA, based on data from the Ministry of Agriculture.

[1] The authors are respectively, Director of the Foundation for Promotion of Cooperatives, Agronomist of the Foundation in El Salvador, and Agricultural Economist of the FAO, Guatemala.

Eighty percent of the arable land is in agricultural use, but 90% of the farms are of subsistence types —too small to adequately support a family. The farmers must supplement their income from other sources (Table 2).

TABLE 2. Distribution of average incomes among tenancy groups in El Salvador.

	Income per family
Laborers (land less)	US$ 230
Microfarms	$ 300
Subfamily farms	$ 420
Family farms	$ 1,410
Multifamily farms (middle size)	$ 7,100
Large multifamily farms	$25,750
Average	$ 580

SOURCE: GAFICA, based on information supplied by the Ministry of Agriculture.

Large farms are rare, and small units predominate in the areas of Cuscatlan and Chalatenango where the FPC work is concentrated (Table 3). The area has a dry season of 6 months (Table 4). An inspection of monthly temperatures over a 12 year period for San Salvador (700 meters above sea level) shows the lowest minimum to be 60.4°F in February and the highest maximum at 89.8°F in April. The highest average monthly temperature is 75.9°F in April and the lowest average is 71.2°F in December and January. The farms involved in the FPC program are located for the most part in rocky, eroded areas that are low in fertility and badly in need of conservation practices.

TABLE 3. Distribution of farms according to size in El Salvador.

Type of farm [1]	Salvador as a whole		Cuscatlán		Chalatenango	
	No.	Area	No.	Area	No.	Area
Subfamily	207,299 (91%)	346,769 (22%)	14,705 (95%)	22,532 (38%)	17,864 (88%)	34,467 (23%)
Family	15,235 (7%)	326,054 (21%)	593 (4%)	11,775 (20%)	1,854 (10%)	39,752 (26%)
Multifamily	4,048 (2%)	532,406 (33%)	116 (1%)	14,319 (24%)	459 (2%)	56,873 (37%)
Multifamily-large	314 (–)	376,798 (24%)	8 (–)	9,927 (18%)	20 (–)	21,409 (14%)
Total	226,896	1,581,428	15,422	58,553	20,197	152,271

[1] Size of farms, in general, is related to amount of labor hired. Therefore, groups have been classified according to labor force, and thus, to number of families supported by these farms. Here are listed those ranging from the subfamily types, too small to support a family (less than two man/year), to multifamily types, employing more than four workers during the year. As the Census does not present data directly relating farm size to labor force, the classification is as follows: subfamily farm with less than 10 hectares, family size with 10 to 50 hectares, multifamily with 50 to 500 hectares, and large multifamily farms having more than 500 hectares

SOURCE: Censo Agropecuario, 1961.

TABLE 4. Monthly rainfall distribution in mm (30 year average).

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Central Zone	Max.	35	34	82	357	445	619	559	471	570	424	143	78	2,471
	Mean.	5	4	8	54	200	328	337	313	352	217	38	9	1,866
	Min..	—	—	—	—	74	141	126	120	202	43	—	—	1,166
National	Ave.	3	1	7	36	194	338	292	290	367	248	39	7	1,822
%		0	—	0	2	11	19	16	16	20	14	2	0	100

SOURCE: National Meteorological Observatory, El Salvador

The average *per capita* income of El Salvador is about US$300* per year, but for the small farmers in the region discussed here, the total income *per family* hardly totals that amount.

Initiation of the Program

The present FPC program had its origin in 1955, when Father Maeda founded a cooperative in Tamanique, in the province of La Libertad. Basic economic and social characteristics of the region included the following: 1) most of the farms were operating at a subsistence level, 2) about 80% of the farmers had less than five acres to cultivate and were obtaining average yields varying between 700 and 900 kg of corn per hectare. A few merchants customarily bought up the corn and sorghum before harvest at a price of $1.50 per 100 pounds, which is less than half of the normal market price. Thus the average income per farm family was below $200 per year.

A savings and credit co-op seemed to be the solution and was begun with a capital of $300 and 42 members. The first objective was to help the farmers to avoid selling their crops at reduced prices at harvest time. Soon it was obvious, however, that this approach alone would not solve the economic problems. Additional funds were needed, and even more serious, the required technology was not available.

* Unless otherwise indicated, all prices have been converted to US dollars to facilitate international comparisons.

Yields of the principal crops, corn and sorghum, were about 850 kg/ha. These low levels suggested that new farming techniques could greatly increase yields. Technical assistance from the Ministry of Agriculture was asked, and an agricultural technician was furnished. Thanks to his visit and recommendations, the group was able to obtain a favorable yield. Unfortunately, this technician was unable to continue because the zone was not included in the plans of the Ministry of Agri culture.

In 1962, Ing. Jesús Merino Argueta joined the program, and with his collaboration it was possible to successfully demonstrate the usefulness of the new technology. He initiated the agricultural program in 1963, providing technical assistance to 98 members of two cooperatives located in the poorest area of the Department of Cuscatlan. At first, Merino Argueta worked only on Saturdays and then on Sundays also. During the week he worked as a technician with the Ministry of Agriculture. In this way, the program was begun and the original goals and strategy developed.

Goals of the Program

The originally proposed savings and loan cooperatives offered a partial solution for credit needs. However, visits in the rural areas indicated that some of the farmers in the northern zone of the country were so poor that they did not eat tortillas made of corn for more

than three months of the year. The rest of the year they subsisted mainly on sorghum tortillas and toasted sorghum kernels. Frequently in the last months before harvest they had to search for fruit in order to survive.

The second stage of the program, initiated in 1963, was specifically directed to attack this problem of hunger. The aim since then has been to raise agricultural production and at the same time increase profits for the farmers.

Having proven the feasibility of the original objectives, the program now has begun to include secondary goals beyond the production of crops. Specifically, the program includes the following activities:

a) Building of a factory for concentrated feeds in Chalatenango with a capacity of 230 tons monthly.

b) Production of hogs in the poorest areas of Chalatenango, with distribution of feeder pigs to the farmers.

c) Establishment of 16 marketing centers for the purchase of grain in areas where the FPC operates in order to reduce the price fluctuations for the small farmer.

d) Establishment of a farm school to train leaders in cooperative and agricultural techniques.

e) Production of improved seed for the exclusive use of the members of foundation cooperatives.

Once the problem of raising the farmers' income is solved, the Foundation will launch work to improve rural housing, one of the country's serious problems. It can be said that the main work of FPC has been to better the life of the campesino, using the agricultural program as a base for a more comprehensive approach.

STRATEGY EMPLOYED

Organization

The FPC program is based on the formation of agricultural cooperatives. A great effort is made to organize them well. To start a cooperative, the participation of 25 to 30 members is required. Before talking about agriculture, an effort is made to show how they can join together through a cooperative and work toward common goals. During this period they should come to fully understand the methods and philosophy of cooperative endeavour. This phase usually takes from four months to a year and consists of a series of meetings with the interested people in their own community. This preparation is basic for the later success of the agronomists' efforts. A well organized group works efficiently and rapidly. Experience has shown that if a cooperative is badly organized, the agricultural program also will fail.

Credit

In order that the instruction provided by the agronomist may be effective, the foundation provides each cooperative with fertilizers, improved seeds, insecticides and small agricultural implements. The administration of this program is centered in the office of the Foundation in San Salvador.

The Cooperative makes direct loans to the members for purchase of land, for land preparation, for cultivation and other production costs. In these cases, the Cooperative provides the member with the necessary credit based on the agronomists' calculations.

As can be seen in Table 5, the Foundation has been able to increase its line of credit over the last six years from US$2,400 in 1963 to US$240,000 in 1969. Only 10 percent

TABLE 5. Activities of the Foundation for Promotion of Cooperatives (FPC), 1963-69.

Year	No. of members helped	Maize area (ha)	Sorghum area (ha)	Credit provided (US$)	Fertilizer	
					Tons	Value US$
1963	98	45		2,400	21	1,645
1964	541	331		28,000	158	12,155
1965	1,500	692	207	57,000	330	25,392
1966	5,125	1,829	549	121,000	871	67,153
1967	7,493	2,413	965	138,000	1,150	88,589
1968	8,420	2,947	1,176	168,000	1,404	108,200
1969	10,500	3,850	1,925	240,000	1,834	141,346
1970 (est.)	11,500					

NOTE: It is common practice to plant a native sorghum variety associated with maize. It resists drought and its white grain is of high quality. Just with the residual fertilizer effect, when corn was planted previously and varying the planting date from May-June to July-August, it is possible to obtain a 50% increase over the yield average of 850 kg/ha.

of this amount represents the FPC's own funds, the rest being loans and grants. Several commercial firms have shown a true interest and great confidence in the Foundation by providing products on credit. At the end of 1970, the Foundation will be able to pay its creditors at least 80% of the amount owed.

In terms of the percentage of loans recuperated, a major increase has been observed during the present period. During the first years, 1964-67, unrecuperated loans amounted to 6% to 7% of the total, due mainly to the organizers lack of experience. This percentage decreased to 4 percent in 1968-69. The largest problem now is in the recovery of old loans. The greater understanding of each farmers' problems by the five Foundation technicians has helped greatly in lowering the percentage of defaults. With seven technicians working with the farmers in 1970, it should be possible to lower the number of unpaid loans even further.

Programing the Work

If a program is to succeed, it requires continuing supervision by an agronomist. Ing. Argueta worked alone until 1966 as the program's first technician, assisting more than 1500 members on Saturdays and Sundays of each week. This was possible only because of well organized groups. The groups which he organized met at his call at any hour or day. These efforts became well known and MISERIOR (German Bishops organization for underdeveloped countries) recently has provided substantial financing, permitting the hiring of an ingeniero agronomo and four full-time intermediate level technicians.

Training of Personnel

In 1964, three young men working as voluntary leaders in the program were sent to Panama to attend courses on cooperatives. On their return they became extension workers within the cooperative movement, forming and advising new groups. Now they select leaders of the different cooperatives and provide special courses for them in cooperatives and agriculture. They taught two courses in 1968 and five in 1969. The courses are of one or two weeks duration, with a cost of $1.80 per day paid for the students by the Foundation. These trained leaders then serve as assistants to the agronomists and cooperative extension workers. While these courses have provided excellent results, lack of funds has limited the number of courses.

Marketing Produce

Some cooperatives have now overcome the problems of production and have a small surplus of grain for sale. A field study has indicated a relatively high percentage of members who sell their products to intermediaries at a price of $1.50 to $2.00 per 100 pounds (US$33 to $44 per ton). These intermediaries then sell the products on the consumer market at double the price paid.

If the Foundation is able to obtain the necessary funding, it will develop 16 small purchasing centers with a capacity of 120 to 230 tons each, and these centers will begin operating in 1971. The Foundation proposes to pay the member an advance of $62.00 per ton for the products brought in, remaining obligated to pay the remainder after selling the products in previously selected markets. Administrative costs will be deducted at the rate of US$5.50 per ton and a small fee per ton will be retained for capitalization.

Participation of State Organizations

The Foundation has asked repeatedly for the collaboration of other national institutions; however, in the majority of cases these requests have proven unsuccessful.

DIFFERING EXPERIENCES WITH TWO COOPERATIVES

In this section, two cooperatives that received the same interest and support from the Foundation are compared. One organization, in Miraflores, has been a success; the other, in Ciudad Arce, has been a failure. The question is, why?

In Ciudad Arce many members have not repaid their loans and community interest has not been aroused. There is little group feeling after four years of help and many farmers believe that they can now dispense with the agricultural techniques that have been taught them. On the other hand, in Miraflores through the production of tomatoes the 120 members have succeeded in raising their yearly income by 500%, to a level of $1,200 per family. In this cooperative, there had been problems with credit when the leaders allowed members to enter without adequate previous preparation. However, they were required to pay their debts as a condition for the continuation of advisory services and credit by the Foundation. The cooperative has responded by liquidating its past debts over a two-year period and is paying recent loans on time.

The failure in the first community seems due to the lack of confidence of the people.

They had previously formed a cooperative which was badly managed, and the people now seem to have littlo interest in a new organization. Also, the community is close to an experiment station, through which the farmers believe they may learn sufficiently on their own, without the strict discipline and experience of the Foundation technicians.

The community of Miraflores had not previous experience with the technicians or the cooperative movement. Due to this, they felt honored from the start with the attention paid by the Foundation. The results have been more than satisfactory and the members now are dedicated completely to the organization and the practices which they have been taught.

SCOPE OF THE PROGRAM

Economic Aspects

Global estimates, comparing 1969 with 1963, provide a general idea of the increased earnings due to the use of modern agricultural techniques.

In the Chalatenango zone, where many cooperatives are located, there are few natural resources and soil fertility is low. Without technology, corn yields were only slightly more than 850 kg/ha. At a price of $79.50 per ton, gross earnings were $67.50 per hectare. Subtracting costs of approximately $56.50, left a net earning of only about $11.00 per hectare (see Table 6). In the case of lower prices of $69.50 per ton the calculated net earnings were about US$3 per hectare. Clearly, under these conditions, the risk of a net loss is great when a charge is included for the farmer's labor.

On the other hand, with the recommended techniques, a yield of 2,500 kg/ha is feasible. The gross income per hectare at $79.50 per ton of corn amounts to almost $198, while the costs are about $152.00. The increase in costs stems principally from the use of fertilizer, better seed, and better preparation of the land, which are paid in part through credit facilities. The value of the family labor is largely theoretical, also in this case, because of limited alternatives. However, if we deduct increases of $45.45 for labor, $45.10 for inputs and $5 for land rent there is still an increase in net earning of about $35 per hectare assuming the same minimum price of $79.50 per ton in both cases. An additional increase is obtained from the production of sorghum. The extra costs are small as no fertilizer is applied to sorghum; it yields satisfactorily with only the residual effects of the fertilizer applied to maize.

TABLE 6. Estimate of costs and returns per hectare in corn production in the area of the FPC program in El Salvador, with and without improved technology.

Total cost per hectare	Non technified	Technified
Land preparation	US$ 4.50	US$ 9.50
Planting, furrowing, fertilization	1.50	8.70
Land preparation and cultivation	8.50	16.70
Insecticide application	—	4.00
Plant doubling	1.00	4.00
Harvesting	3.00	8.85
Shelling and sacking	3.00	11.80
Transportation	—	3.50
Total labor	(21.50)	(67.05)
Seed, 16 kg	5.00	6.50
Fertilizers	—	38.30
Insecticides	—	5.30
Total inputs	(5.00)	(50.10)
Land rent	(30.00)	(35.00)
Total cost per hectare	56.50	152.15
Total value produced/ha*	67.50	198.00
Net income per hectare	11 00	45 85

* Average yield in 1963 (non technified) was 850 kg/ha; for 1969 (technified) it was 2,500 kg/ha. For purposes of comparison the same price of US$79.50 per metric ton of corn is calculated for both years. This gives a slightly constructive bias as some progress has been made during this interval in improving the marketing of corn. The average area per farm is 0 7 hectares. Corn is planted in May and harvested in October.

In terms of the total program, 3,850 hectares were planted to corn in 1969. The increase in net income on this area amounted to nearly $135,000. If the additional labor income that stayed within the area is added, the total is over $300,000. If we add to this the profits of some 700 producers in the tomato program, who netted between $90 and $200 each for an average of $150 per family, we have an additional $100,000. All of this $400,000 represented additional income for the areas where the FPC is operating. For the national economy, this increased income signified more purchases of both agricultural inputs (see Table 7) and consumer goods, giving employment to even more people. This factor is of special importance in a country such as El Salvador, with its dense population and problems of under-employment.

The total cost of the program in 1969 was under $50,000. More than half —about $25,000 — was accounted for by the salaries of 17 full-time employees —1 engineer, 2 agronomists, 4 technicians in cooperatives, 3 accountants, 2 secretaries, 1 person in charge of agricultural products, 1 driver, 2 warehouse men, 1 part time agronomist and 1 director general. The remainder included vehicles, gas,

TABLE 7. Value of inputs used in the FPC corn program in El Salvador.* US$.

	1963 (45 ha)	1964 (331 ha)	1965 (692 ha)	1966 (1,829 ha)	1967 (2,413 ha)	1968 (2,947 ha)	1969 (3,850 ha)
Fertilizers							
Ammonium Sulphate	$1,229	$ 9,082	$18,970	$50,170	$ 66,182	$ 80,832	$105,600
Superphosphate	416	3,073	6,422	16,983	22,407	27,368	35,746
Insecticides							
Aldrin	307	2,270	4,742	12,542	16,546	20,208	26,400
Sevin	154	1,135	2,371	6,272	8,273	10,104	13,200
Seed	320	2,365	4,940	13,065	17,235	21,050	27,500
Total	$2,426	$17,926	$37,446	$99,032	$130,643	$159,562	$208,446

* The amounts of physical product increased from 1963 to 1969 in the following manner: Ammonium sulphate, 17.7 to 1,518 metric tons; superphosphate, 3.7 to 316.3 metric tons; insecticides, 1,235 kgs to 196,260 kgs; and improved seed, 736 kgs to 63,250 kgs.

repairs, production of improved seed and expendable items. Obviously, the direct economic benefits, estimated roughly at $400,000, greatly exceeded the costs.

The program depends on donations and outside loans to cover most of its costs with about 68 percent received from outside sources (principally from Germany, Belgium, Holland, and the Rockefeller Foundation). Approximately 20 percent of the costs are obtained from profits on sales of agricultural products, and the remainder is contributed by the cooperatives and churches in San Salvador.

Social Aspects

Another important benefit of the program, though difficult to measure, is the ability of the people to work together. They learn to value their common efforts and find dignity in their work. A feeling of responsibility is created, which is reflected in the use of credit. In spite of adverse conditions, the majority of the groups have repaid their loans in full, and the percentage of unpaid loans has been reduced to about 6 percent in the others.

MAIN FACTORS FOR SUCCESSFUL OPERATION

In analyzing the operation of the program, it is of interest to identify factors that have been keys to its success. The following points have been crucial in this sense.

1. *The organization of groups is a pre-requisite* for work by the FPC —groups that understand the nature of cooperative work. Under no circumstance will the FPC work with individuals.

2. *Confidence of the people* is crucial. This is achieved through regular contact with the FPC technicians and through dedicated local leaders.

3. *Confidence is also achieved through the farmer's successful experiences with the new technology;* for example, the demonstration that a second harvest of grain sorghum is feasible if planted in August, has helped gain the farmer's confidence.

4. *Supply of good quality production inputs on time* — seeds, fertilizers and pesticides. Some competitors have offered these inputs at lower prices but as these inputs often were also of low quality, confidence was strengthened in the FPC.

5. *Regular and punctual visits of the technicians* are indispensable so that the farmers will not feel deceived. Interchange of ideas in the field is important for all participants. A regular schedule of visits is required for good organization.

6. *The small demonstration plots on members'* fields have encouraged them to follow the same practices on their own.

7. *The help of the local leaders,* for example the priest, is a tremendous help in strengthening the cooperative spirit.

8. With a growing number of groups, the *responsibility for local organization has been turned over to local leaders.*

9. The participation of *local technical assistants* has been the solution for expanding the program with small available resources.

10. The decision to *emphasize agricultural production,* and thereby concentrate efforts on activities that directly affect the daily lives of the small farmer.

11. *The support of the national institutions* —at least, moral support— and recognition of the fact that the social work carried out by the Foundation, is indispensable for developing a program of this kind.

CONCLUSIONS

In summary, it can be said that the Foundation's program has brought about favorable changes in the participating groups even though cooperatives in El Salvador, as in other Central American countries, lack prestige because of bad management of funds in the past. This

first stage now has been surpassed and such enthusiasm has been created that it is impossible to meet all of the demands for organization of new groups. The problem now is to avoid making commitments that it may not be possible to adequately care for. For this reason, each technician in the Foundation has been provided with a previously trained assistant to help teach fellow cooperative members the most modern agricultural production practices.

In this way at least part of the problem has been solved. However, the lack of funds continues to restrict the expansion of the Foundation's work to other communities in equal need.

discussion

Q. In extending credit, what is the type of guarantee?

A. Well, the farmer has some stock in the cooperative, although the credit given to him is four or five times more than his own stock. A sense of responsibility is created through cooperative work.

Q. How many small holders are there in your program who are using fertilizers?

A. From our records, we know that at present we have approximately 11,500 organized in cooperatives. However, not all of the fertilizer is used by the cooperators; there is an influence in the surrounding communities, so the number surpasses the 11,500 members.

Q. How many more do you think there are?

A. It is not possible to make an accurate estimate as there is an influence on many who are not associated, but who do benefit form the co-ops in the community since they have easier access to fertilizers, seeds, etc.

Q. Is credit given to anyone who requests it?

A. No, credit is given exclusively to members. However, others may buy their inputs at the co-ops.

Q. What is the interest rate on this credit?

A. It is 12% per year. The Foundation gets credit from other agencies and this is passed on to the co-ops.

Q. How does your 12% rate to farmers compare to the rates in government institutions?

A. It is acceptable. The government credit sources generally charge between 8-9% per year in the case of fertilizers.

Q. And the other credit sources, what is their rate of interest?

A. The banks charge 11%.

Q. Then, your co-ops charge a little more.

A. Yes. They have to do this because the co-ops, in turn, receive these inputs on credit. The rates on commercial loans are between 8 and 11%, so the co-ops, due to administration costs, have to go higher than that. I would also like to add that when the fiscal years ends, the co-ops distribute the profits among their associates, according to their participation during the year. This way the member recovers part of the interest that he has paid for his credit.

Q. As a point of interest in line with this same problem, a device in the credit organization here in Mexico has been the creation of solidarity groups (grupos solidarios). Members are requested to take joint responsibility for the debts of every member of the group, in order to get the credit. This is a legal contract, and the procedure has been applied with supervision rather successfully. In Mexico this arrangement has accelerated the flow of credit to small farmers. Are there any objections to such an approach and what can be done to overcome them.

A. Yes, it is unfortunate that in El Salvador and perhaps other countries in Latin America, when we try to solve problems of small farmers, not in a religious or political sense, but with good intentions and awareness of our national needs we are looked at with skepticism by the government. We are convinced we are working for the benefit of the people. However, the response of the private sector, and even the government, would make it appear that they are interested in keeping the farmers in poverty, at their present low levels of subsistence. I want to point out that hav-

ing a priest directing the program does not mean that our goals is to proselitize.

Q. Have you informed the government about your needs? Have you requested its help?

A. Yes, indeed. However, we have not obtained a positive response. I should mention that there is a situation which damages us. Since there is a Christian Democratic Party among the political parties in the country, some tend to identify us with the party, as if we were playing politics for that party.

Q. Is it that you are receiving no support, or is there open opposition in the form of government policy or action.

A. No, there is not an open opposition. There is just a lack of interest, indifference; we do not receive the support of government.

Q. Is there a support price for maize in El Salvador? How does it compare to Mexico?

A. There is one, but quite frustrating since it is not always maintained.

value of agronomic research in a project to rapidly increase crop production

ANTONIO TURRENT [1]

EFFICIENT ALLOCATION OF limited resources —land, labor, and capital— in a program to increase crop yields, requires a detailed understanding of the important crop production relationships.

There are certain crop production factors that the farmer can afford to modify in the short run. These factors include the rate, time and method of applying fertilizer, plant genotype, population density, date of planting, insect control, land preparation and cultivations. Other production factors cannot be modified economically by the farmer. These include the amount and distribution of rainfall, frost, hail, strong winds and important soil morphology characteristics.

The farmer needs detailed and reasonably reliable information on these uncontrollable factors for his own farm in order to efficiently allocate his land, labor and capital resources.

Also, the farmer should be able to predict with reasonable certainty how the controllable production factors will affect the yield of crops on his land. As there is an interdependence among the production factors in their effect on yield, the farmer must be able to predict responses for specific levels of the different controllable factors. We know, for example, that the response to nitrogen for a given soil and climatic condition depends upon the genotype, plant density, date of planting, etc. Due to this interaction among the production factors in their effect on response, it is necessary to understand in detail the following function:

$Y = f$ (fertilization, date of planting, plant genotype, population density, etc.) for a given ecological system.

If a farmer had a quantitative expression for the above function available for his land he would be able to achieve maximum returns from his limited resources by applying certain principles of agricultural economics. Within the range of decreasing returns, the farmer could maximize his returns to capital by distributing it in such a way that the last dollar allocated to each of the controllable factors —fertilization, plant genotypes, population density, pest control, etc.— would produce the same increase in yield.

Uncertainty and Factors That Cannot Be Modified

However, the farmer can expect to have only a partial understanding of the uncontrollable factors for his land. He may have reliable information on soil morphology and native fertility, but cannot know meteorological phenomena with any reasonable certainty. Therefore, any allocation of resources will be only partially successful and will differ from the opti-

[1] Soil scientist and advisor to the soils program of the Puebla Project, International Maize and Wheat Improvement Center, (CIMMYT), Mexico.

mum in the degree that the farmer's prediction of meteorological phenomena deviates from actual events. He is faced with a situation of uncertainty as to what the returns on his investment will be.

For example, in unirrigated agriculture, the farmer's return on his investment is reduced by his inability to predict the quantity and distribution of rainfall. The degree of this reduction is affected by soil physical properties and native soil fertility. A rainfall schedule that limits crop yields will reduce the farmer's return less when his soil is highly fertile, deep, relatively level, permeable and with a high moisture retention capacity. With such a soil, the farmer has to apply very little fertilizer and therefore risks only a small out-of-pocket expenditure. The soil characteristics favorable to the absorption and retention of moisture also assure a more efficient use of the rainfall.

Well-conducted experiments are needed as a basis for deciding how much of a given resource should be used in unirrigated agriculture. It is necessary to determine how crop response to the controllable factors may be influenced by the range of uncontrollable factor values observed in the region of study. Specifically, it is necessary to measure how the response to fertilization, genotype, plant population, date of planting, etc., may change as a function of the fluctuations in rainfall, soil morphology, etc., that are characteristic of a region.

Interdependence Between Knowledge and Development

An understanding of these production relationships can be obtained only through intense and lengthy research. However, it is not necessary to wait until all of this information is accumulated before such knowledge can contribute to agricultural development in a region. It may be a continuing process and contribute in a series of steps, each leading toward a more rational development program for the region.

Where, then, is the best location for conducting the search for knowledge on production practices? An experiment station provides ideal conditions for detailed, precise studies of production relationships. However, such studies also may be conducted at sites distributed geographically throughout the region of interest. Although this latter approach may mean greater cost and some sacrifice in detail and precision, we believe that it is necessary to carry out much of the production research at sites distributed throughout the region. Such a course is dictated by the great variability in the uncontrollable factors of production. If it were possible to find all relevant variation in soils and climate within a region at a single station site, then it would be reasonable to conduct the production research at the experiment station. However, such a situation is seldom, if ever, encountered.

Also, with respect to non-agronomic considerations, production research conducted at the experiment station greatly restricts the movement of knowledge to farmers and the feedback of his concerns to the researcher.

The Case of the Puebla Project

Let us now examine the Puebla Project where the use of knowledge to increase corn production on a commercial scale was begun in 1968. Production research conducted in the area during 1967 defined, to a first approximation, the practices to use in producing unirrigated corn.

The agronomic research that has been carried out in the Puebla Project since 1967 is divided into two programs: (1) genetic improvement and (2) the study of production relationships.

The genetic improvement program seeks to develop highly productive varieties for both short and long growing seasons that have a wide ecological adaptation. Materials that contain the opaque-2 gene also are being developed.

Several approaches are being employed in the breeding program. The conventional method and a procedure involving "cryptic double crosses" are being used to produce high-yielding hybrids in a very short period of time. Also, existing commercial varieties as well as varieties recently produced by the Instituto Nacional de Investigaciones Agrícolas are being evaluated. In this way it is hoped to have improved genetic materials in commercial production in five years.

Another part of the breeding program involves the use of mass selection for prolificacy in a convergent-divergent process. This method will require more time to develop superior varieties than the hybrid program. However, it is expected that the open pollinated varieties developed through mass selection will be more satisfactory than hybrids for the region.

In order to advance two generations each year, crosses are made in the project area during the summer and at an experiment station at a lower elevation during the winter.

The evaluation of the commercial and experimental varieties, as well as the work on mass selection, is done at carefully selected sites in the project area.

Objectives of the program for the study of production relationships include (1) the identification of controllable and uncontrollable factors of production that significantly affect yields and (2) the generation of quantitative information on important production relationships.

At present, the following controllable factors are of interest: (1) time of initiating land preparation because of its importance in conserving residual soil moisture, (2) rate and time of applying nitrogen and phosphorus, (3) plant density, (4) date of planting, (5) genotype, and (6) weed control. With respect to uncontrollable factors, a broad understanding has been developed of the characteristics of the soils in the area. The combined action of soil morphology and rainfall distribution as an influence on annual fluctuations in crop response is better understood, also.

Let us now examine the chronological development of the research to produce new technology.

Research in 1967

The genetic improvement program began in 1967 with an evaluation of the yielding ability of 59 introduced materials and eight local varieties. They were evaluated at several locations distributed over the project area. The average yields obtained at six sites with six of the higher yielding introduced materials and three of the better local varieties are presented in Table 1.

TABLE 1. Grain yields at 12% moisture of 9 varieties tested at 6 sites in 1967. Puebla Project.

	Days to silking	Yields kg/ha
INTRODUCED VARIETIES		
H-28	93	5322
H-127	92	5220
H-125	100	5127
H-129	103	4912
Xolache S. M. C.	100	4492
Batán S. M. C.	101	4220
LOCAL VARIETIES		
Colorado Salvatori	91	5436
Pinto Salvatori	96	5150
Blanco Salvatori	105	4600

The results obtained in these experiments suggested to the plant breeders that the commercial hybrid H-28 was potentially useful for favorable producing conditions in the area. However, because of the great ecological variability in the region, they felt it was important to investigate the usefulness of local germ plasm in the breeding program. Also, in these studies it was possible to identify the outstanding local and introduced materials for use in developing improved varieties for the area.

Five hundred cryptic double crosses within a population of the local variety Pinto Salvatori also were made in 1967. Ninety-four of these crosses, together with the parent lines, were saved for testing in the following cycle. It was expected that some of these crosses might prove outstanding and could rapidly be increased and distributed for use in early plantings.

During the winter of 1967-68, families of sister crosses were prepared using S1 lines of Pinto Salvatori and H-28 as females with selected plants from five of the outstanding varieties in the 1967 experiments used as males. A total of 68 crosses were made. These crosses were evaluated in 1968 and the best materials were used to produce short season hybrids for immediate multiplication and use in the area.

The soil fertility work in 1967 included experiments at 27 locations to measure corn response to nitrogen, phosphorus, potassium and zinc. One-tenth of the nitrogen and all of the phosphorus, potassium and zinc were applied at planting; the remainder of the nitrogen was applied at a side-dressing at the time of the second cultivation. Local varieties were planted in all experiments at a rate providing 50,000 plants/ha. The estimated economic optimum rates of nitrogen and P_2O_5 (phosphorus) in 18 experiments, as well as the estimated yields corresponding to the optimum rates, are shown in Table 2. No response to potassium or zinc was observed. Daily rainfall was recorded, the soil profile was described and periodic observations on plant wilting were made at each location.

Based on results obtained in 1967, it was decided that, as a first approximation, the following practices could be recommended:

A. For farmers whose investment was covered by crop insurance: 130 kg/ha of nitrogen, plus 40 kg/ha of P_2O_5 applied in the same manner as in the experiments; local varieties with a plant density of 50,000 plants per hectare.

B. For farmers without crop insurance: the fertilizer treatment, 100-30-0, was recommended.

TABLE 2. Economic optimum rates of fertilization in 1967. Puebla Project.

Experiment number	Optimum economic rates		Grain yield * kg/ha
	N kg/ha	P_2O_5 kg/ha	
PS-6701	0	0	6607
PS-6704	171	0	5018
05	173	0	4716
06	157	0	4031
07	147	0	3761
08	221	128	6907
09	79	22	2568
10	87	0	1952
11	185	109	5098
12	116	0	2610
13	0	0	2890
14	0	0	630
15	0	22	3336
16	171	25	5882
19	118	0	3047
20	147	0	4121
21	87	0	3799
25	153	0	3930
Average	112	17	3939

* Grain with 12% moisture.

Average increases in yield for the first recommendation were estimated at 3.3 ton/ha and for the second, 2.6 ton/ha.

Research in 1968

The genetic improvement program in 1968 inclu. ' the following activities:

a) Formation of a long-season composite by mechanically mixing seed of nine varieties which had performed well in 1967. This composite was planted at 4 locations distributed throughout the area so as to sample ecological variability. A mass selection for prolificacy was made in each planting.

b) Formation of a short-season composite by mechanically mixing seed of nine varieties which had performed well in 1967. This composite was planted at 4 locations in the area and mass selection for prolificacy was made at harvest.

c) Comparison of the cryptic double crosses and families of sister crosses with local varieties.

d) Formation of a composite containing lines with the opaque-2 gene. This composite was planted at one location. At harvest a mass selection for prolificacy was made and opaque-2 grains were separated.

Research on production practices in 1968 included several kinds of experiments:

a) Rates of nitrogen, phosphorus and population density, using local varieties.

b) Dates of planting using 6 varieties at one level of fertilization.

c) Rates and times of applying nitrogen and phosphorus.

d) Depths of cultivation.

e) Rates of nitrogen fertilization of corn planted in strips between rows of fruit trees.

Experience obtained in 1968 provided information for the second approximation to the package of recommended practices for producing corn in the region.

Two categories of soils with major differences in morphology were recognized. The recommended fertilizer practice for corn grown on deep, well-drained soils was 130 kg/ha of nitrogen plus 50 kg/ha of P_2O_5 with one-fifth of the nitrogen and all phosphorus applied at planting time and the rest of the nitrogen applied at the second cultivation.

The recommended practice for soils with a compacted subsoil was 110 kg/ha of nitrogen plus 50 kg/ha of P_2O_5 applied as indicated above. For both edaphic categories it was recommended that local varieties be used, with plant densities of 50,000 plants per hectare.

Third Approximation for Recommendations

In general, the research program in 1969 was a continuation of that in 1968. The results obtained in 1969 allowed a third approximation to the recommendation for fertilization and plant density. Specific recommendations were made for four categories of soils in terms of morphology. These recommendations are presented in Table 3. Also, at this time, a long-season hybrid seed produced from the cryptic

TABLE 3. Fertilizer rates, time of application and population densities as recommended in 1970.

Distinguishing soil characteristics	Time of applying fertilizers			Total amount kg/ha	Population density plants/ha
	Planting N-P_2O_5 kg/ha	First cultivation N-P_2O_5 kg/ha	Second cultivation N-P_2O_5 kg/ha		
Deep, with a loamy B horizon	30-50	0-0	100-50	130-50	50,000
Compacted non-sodic subsoil	20-50	0-0	90-50	110-50	50,000
Compacted sodic subsoil	0-30	60-0	0-0	60-30	40,000
Deep, with a sandy B horizon	0-0	80-0	0-0	80-0	40,000

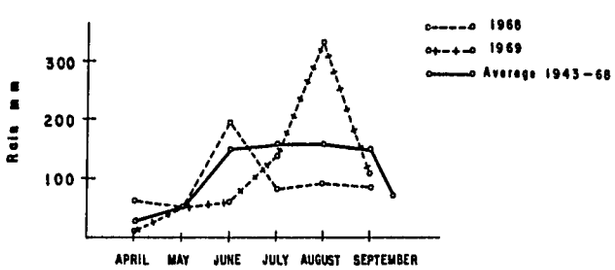
double crosses became available. This seed was planted on a small commercial scale in 1970, mainly for the purpose of further testing against local varieties.

The maize improvement program is being continued in 1970 along the lines described for 1968. Research on production practices includes an experiment comprising all combinations of two levels of rate and time of applying nitrogen and phosphorus, date of planting, variety, and plant density in addition to the program carried out in 1969.

Experimental Results for 1968 and 1969

Let us now combine the 1968 and 1969 experimental results for further analysis. The rainfall patterns during the corn growing season in 1968-1969, and the 1943-1968 average are shown in Figure 1. These data are averages for several locations. In 1968, rainfall

Fig1 RAIN SCHEDULE IN PUEBLA



was above average in April and June, and below average in the other months. In 1969, rainfall was below average in April, May, June and September, and considerably above average in August.

Genetic Improvement

The data obtained with the long-season genetic materials in 1968 and 1969 are summarized in Table 4. In 1968, six of the cryptic double crosses clearly outyielded the checks. The parent lines of these six crosses were selfed and the seed mixed mechanically to form two composites. These composites were crossed in the winter of 1968-1969 to form a new material designated composite A x B. This material was used in small, commercial plantings in 1970.

Mass selection for prolificacy, begun in 1968, was continued in 1969. In addition, the

TABLE 4. Yields of improved, long season genetic materials.

	Days to silking	Grain yields * 1968 kg/ha	Grain yields * 1969 kg/ha
CRYPTIC DOUBLE CROSSES			
113	93	8825	
358	100	8825	
246	94	8524	
275	98	8563	
205	99	8418	
88	95	7649	
MASS SELECTION			
FIRST CYCLE	102		4769
INTRODUCED			
INIA H-128R3	114		5276
INIA H-129R3	117		5247
INIA H-110E	106		4993
CHECKS			
INIA H-129	110	7491	4675
PINTO SALVATORI	101	6886	4439
LSD 5%		379	704

* 12% moisture.

product of the first cycle of selection was planted in the 1969 yield trials. The results given in Table 4 indicate that this selection yielded slightly more than the checks. Also, it is seen that two of the introduced INIA hybrids clearly outyielded the checks and might be considered for immediate distribution in the project area.

A summary of the work carried out with short-season materials is presented in Table 5. The five outstanding crosses clearly out-

TABLE 5. Yields of improved, short season genetic materials.

	Days to silking	Grain yields * 1968 kg/ha	Grain yields * 1969 kg/ha
CROSSES			
309	86	7964	3795
276	95	6793	3841
292		6936	
257	85	6875	3758
333		6790	
MASS SELECTION			
FIRST CYCLE	83		3258
CHALQUEÑO -0_2 C-I	93		3082
INTRODUCED			
INIA H-31E	84		4040
INIA H-26E	88		3605
INIA H-32E	85		3542
CHECKS			
INIA H-28	87	5887	3675
ROJO SALVATORI	81	5789	3555
CRIOLLO LOCAL	81		3062
LSD 5%		277	455

* 12% moisture.

yielded the checks in 1968, but differences were less notable in 1969. One of the introduced INIA hybrids also outyielded the checks. Within one or two years it should be possible to test the crosses, and possibly the INIA materials, on a commercial scale. The short-season variety produced through mass selection did not outyield the checks in 1969.

Agronomic Studies

Economically optimum rates of nitrogen, phosphorus and plant density, estimated from results obtained in the experiments carried out in 1968, are given in Table 6. These experiments are grouped according to the morphological soil condition where they were located. It is seen that higher yields were obtained on the deep soils. The average economic optimum rates of nitrogen and P_2O_5 were 188 and 88 kg/ha, respectively, for the deep soils.

The average optimum plant density was 68,000 plants/ha. The average yield was increased from 1028 to 7482 kg/ha by applying the optimum amount of fertilizer and adjusting plant density to the optimum. On soils with a compacted subsoil, the average economic optimum levels of nitrogen, P_2O_5 and plant population were 129 kg/ha, 70 kg/ha, and 56,533 plants/ha, respectively. This combination of values for nitrogen, phosphorus and plant density increased average yields from 1403 to 5577 kg/ha.

Rainfall in 1968 was quite favorable for corn production. This is reflected in the high yields reported in Table 6. Nevertheless, corn in the experiments suffered from drought an average of 17 days during July and August, which undoubtedly was sufficient to reduce yields. It is interesting to compare the rainfall pattern in 1968 with the average for the 1943-1968 period (Fig. 1). It is seen that rainfall in 1968 exceeded the average in April and June and was less than the average in the other months.

In general the information produced on production practices in 1968 contributed to a better understanding of differences in productivity of the two morphologically distinct kinds of soils. Also, the results were very useful in studying how corn yields on these soils varied as a function of plant density. However, because 1968 was quite favorable for corn production and since frequencies of different rainfall patterns were unknown, the levels of nitrogen and plant density recommended in 1968 were not increased. Rather for the soils with a compacted subsoil, the recommended nitrogen rate was reduced.

The results obtained in 1968 are examined next. The economically optimum rates of nitrogen, phosphorus and plant density are presented in Table 7. Included in the experimental program in 1969 was a geographical region that had been studied in 1967, but not in 1968. This region includes two kinds of soils that differ morphologically from the two previously recognized categories: (1) Soils with a poorly developed sandy B horizon, over coarse parent material, and (2) Soils having a dense B horizon, with columnar structure characteristic of sodic soils.

Only two experiments were carried out in 1969 in the region of deep, permeable soils. The average optimum levels of nitrogen, P_2O_5, and plant density in these trials were 158

TABLE 6. Economic optimum rates and estimated yields in 1968.

Soil characteristics and experiment number	N kg/ha	P_2O_5 kg/ha	Population density plants/ha	Grain yield *	
				Check kg/ha	Optimum kg/ha
Deep soils					
1PS-6806	200	100	70,000	210	7591
07	205	100	70,000	810	9112
08	215	77	88,000	2200	7897
09	189	86	70,000	1280	8300
13	133	76	42,000	640	4510
Averages	188	.88	68,000	1028	7482
With a compacted subsoil					
PS-6810	117	73	46,000	850	3610
11	168	137	70,000	850	8220
12	102	0	53,000	2510	4900
Averages	129	70	56,333	1403	5577

* 12% moisture.

TABLE 7. Economic optimum rates in 1969.

Distinguishing soil morphology and expt. No.	N kg/ha	P_2O_5 kg/ha	Population density plants/ha	Grain yield * Check kg/ha	Grain yield * Optimum kg/ha
Deep, with a loamy B horizon					
PS-6912	137	150	47,000	375	5840
13	180	0	67,600	194	5769
Averages	158	75	57,300	284	5805
Compacted non-sodic subsoil					
PS-6916	94	62	30,000	65	2880
Deep, with a sandy B horizon					
PS-6903	0	0	30,000	1595	1595
04	40	0	30,000	976	2592
05	0	0	30,000	1274	1274
06	137	0	51,000	603	3877
07	114	0	30,000	570	4546
08	70	0	54,000	912	3844
Averages	60	0	37,500	988	2955
Compacted sodic subsoil					
PS-6909	0	37	38,000	68	858
10	15	23	30,000	172	584
Averages	7	30	34,000	120	721

* 12% moisture.

kg/ha, 75 kg/ha and 57,300 plants/ha, respectively. Average yields were increased from 284 to 5805 kg/ha with the use of these optimum levels. Only one experiment was conducted in the area of soils with a compacted subsoil. Optimum levels of nitrogen, phosphorus and plant density at this location were 94 kg/ha, 62 kg/ha and 30,000 plants/ha, respectively. The optimum treatment increased yields from 65 to 2880 kg/ha. These results indicate that 1969 was less favorable for corn production than 1968. In the experiments carried out in 1969, corn was affected by drought an average of 52 days during the period from May to July. This drought corresponded to the period of very low rainfall as seen in Figure 1.

Very interesting results were obtained in the region with soils having sandy B horizons. Corn did not respond to the application of phosphorus, thus indicating that these soils are adequately supplied with this nutrient, at least in years with severe moisture deficiencies when maximum yields do not exceed 4 ton/ha. Results obtained in this region also showed that the required amount of nitrogen was less than that needed in the two categories of soil defined in 1968. The average optimum levels of nitrogen, P_2O_5, and plant density for the trials conducted in this region were 60 kg/ha, zero and 37,500 plants/ha. The optimum practices increased the average yield from 988 to 2955 kg/ha.

Results obtained at two locations on soils with sodic-like characteristics indicate that the productivity of these soils is the lowest found in the project area. Based on the results obtained in 1969, it does not appear economically sound to grow corn on these soils. However, to understand better the significance of the 1969 experiences, it is helpful to examine the rainfall pattern. In August, the rainfall was about double the average and this month corresponds to the period when the grain is forming. As the B horizons of these soils are very impermeable, it is likely

TABLE 8. Grain yield response to rates and time of application of nitrogen fertilizer.

Grain yield * 1969 kg/ha	Grain yield * 1968 kg/ha	Time of fertilizer application: First cultivation kg/ha	Second cultivation kg/ha	Planting kg/ha
0	0	0	370	516
75	0	0	2474	3189
0	75	0	3733	3181
0	0	75	3860	2862
150	0	0	4500	4427
0	150	0	5450	3610
0	0	150	5093	3129
15	0	135		3755
LSD 5%			753	482

* The figures for 1968 and 1969 represent averages of one and three experiments, respectively. Grain at 12% moisture.

that the heavy rainfall created a saturated condition in the upper soil horizon that resulted in an oxygen deficiency for the plant

roots. It may be that in years with less rainfall during August, it is possible to produce significantly higher yields.

Let us look now at what these experiments teach us about rate and time of applying nitrogen. As seen in Table 8, in 1968 it was better to apply 75 kg/ha of nitrogen in the first or second cultivation than at planting time. In 1969, on the other hand, it was better to apply 75 kg/ha of nitrogen at planting time or in the first cultivation. With the 150 kg/ha rate of nitrogen, it was best to make the application at planting time. From these results it is clear that it is necessary to take into account not only the rate but also the time of applying nitrogen in defining a package of practices for unirrigated agriculture. Based on two years of experience it appears that nitrogen application, at the time of the first cultivation has a higher probability of being correct than either of the other alternatives.

The Value of Research

On balance, we can say the following about the contribution that research has made to agricultural development in the Puebla area (1) the agronomic knowledge produced by research now permits a more efficient use of available labor, land and capital, (2) through the genetic research it has been possible to identify and produce genetic materials with greater yield potential than the local varieties now in use and (3) finally this experience has shown that it is possible to generate valuable new agronomic knowledge in a relatively short period.

discussion

Q. In your Table 1 there is a seemingly negative correlation between days to silking and yield. How would you explain that?

A. I think that there is a general positive correlation between yields and length of the growing season. However, there are many other factors that affect production. I would not worry too much at the seemingly negative correlation between yield and days to silk for several reasons. First: very few observations. Second: the extent of the variation of days to silk is rather narrow. Third: several degrees of genotype adaptation are involved.

Q. Do you change recommendation of variety if the planting date gets late in the season?

A. The change of variety as a function of planting date is a common practice among the farmers of Puebla.

Q. In the work done in Jalisco, it has been found that the maize seed from the *Productora* is variable in quality. How carefully are the materials checked in terms of quality and other characteristics which may affect corn?

A. Up to now we are recommending that farmers use their local varieties.

Q. What is the population density for checks?

A. In the experiments involving rates of nitrogen, phosphorus and population densities, the checks for N and P had 30,000 and 70,000 plants/ha.

Q. How many experimental locations in the area?

A. In 1970 we have 22 locations in the producton relationships program and 13 in the breeding program. There is at least one experiment per location. That applies to both programs.

Q. Do you carry out soils tests?

A. We are not using laboratory tests as a basis for fertilizer recommendations. However, our present field studies will provide the methodological basis for calibrating such tests in the future.

methodology and results of evaluation in the puebla project

HELIODORO DIAZ C.
JUAN MANUEL RANGEL [1]

IN PAST YEARS Mexico and other countries have carried out various types of rural development programs. However, the lack of adequate evaluation based on previously established bench marks in respect to natural and human resources has seriously limited the knowledge that could be gained from these experiences. In fact, in very few cases have objective evaluations been carried out at the completion of projects. As a result the degree of success in attaining stated objectives is seldom known.

In the Puebla Project, evaluation was included as an integral part of the over-all plan from the very beginning. Because of the nature of the project, designed to test a model for development, it was felt that the evaluation must include an adequate bench mark as well as intermediate and final studies.

The nature of the evaluation program was decided through extensive discussion among staff and advisers of the project. One point of view maintained that an independent outside institution ought to make the evaluation. Two arguments were presented in favor of this focus:

1. It would be possible to maintain complete objectivity, as the persons in charge of the evaluation would not have a personal interest in the success or the failure of the plan and consequently,

2. The results would be given greater weight by the individuals and institutions that make decisions about agricultural policy in other regions and other countries.

Notwithstanding these two advantages, the ultimate decision was to integrate evaluation into the over-all program and obtain not only before-and-after measurements but alto a continuous feedback of information for the coordinator and technicians in the action program.

With respect to the question of objectivity, it was believed that the essential conditions in this case, as in any type of scientific research, would be: 1) objective criteria, and 2) adequate scientific methodology.

METHODOLOGY USED IN ESTABLISHING THE BENCHMARK

The first phase was to collect the existing information about the region. The 1960 agricultural census provided initial data by municipios in regard to: 1) number of resident families, 2) area sown to corn and its production, and 3) size of the agricultural units, including ejido parcels and private holdings.

Annual data were obtained from the crop reporting service (Dirección General de Economía Agrícola) on area planted to corn and yields obtained. Through discussions with in-

[1] Respectively, Head of Evaluation in the Puebla Project, and Assistant in Evaluation, in charge of objective yield measurements in 1969.

dividuals involved in collecting this data, it was concluded that procedures used would not assure an adequate measure of the year-by-year success of the project. Therefore it would be essential for the project to establish its own bench marks and make its own periodic measurements of progress in increasing yields.

After the harvest of the fertilizer experiments in 1967, it was evident that the Project would be ready to begin the extension aspects of the program by planting field demonstrations in 1968. In order to have adequate reference points for future comparisons a bench mark study was carried out in the winter of 1967-68 to obtain the following information:

1. Corn yields for 1967.
2. Descriptive data on the farmer, his family, size of farm, prevalence of different types of land holdings, diet and levels of farm and off-farm income.
3. The present level of knowledge and use of agricultural technology.
4. Information channels existing in the area.
5. The attitudes of the farmers previous to initiating a development program in which they would play a major role.
6. The infrastructure of the area and the farmers' use of it —the existing programs and functioning of fertilizer distribution, agricultural credit, crop insurance, guarantee prices, and markets for agricultural produce.

These measures were made in large part through a sample survey among farmers of the area.

The Sample Survey

The population of interest in this case was the total number of heads of family operating land in the area. In previous studies done in other parts of Mexico, the census lists by municipio had been employed as the sampling frame. In view of the problems encountered in those studies .and because 8 years had passed since the lists were done for the 1960 census, it seemed prudent to use another basis for the sampling design.

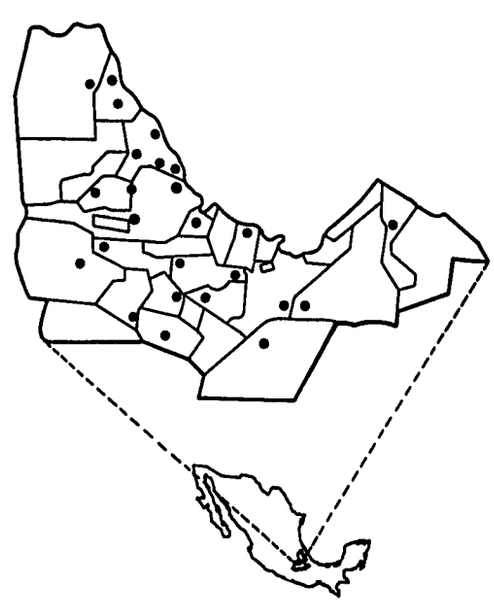
An area sampling technique appeared to be the most desirable and when it was found that aerial photographs had been taken of the region only six months earlier and could be purchased at a reasonable price, a definite decision was .nade in favor of area sampling.

To make the best use of funds available for the field work, it was decided to take a sample in two stages. The sample was selected as follows:

Using a good map of the region, provided by the Mexican Defense Ministry, the outlines of the project area were drawn in. Then 25 points were selected by drawing in coordinates and making the selection of coordinates with a list of random numbers (Fig. 1). These points were transferred to the aerial photos and then 5 x 5 cm squares were drawn around these mid-points in order to obtain blocks measuring one kilometer on each side, or 100 hectare segments. These 25 segments are the first stage of the sample —the primary units. Each segment was photographically enlarged to a size that would permit easy identification of the individual plots, and at the same time make it easy to convert measurements made by ruler on the photo to hectares of area in each plot.

The first step in the field work was to locate the segments. This was accomplished by seeking out reference points in the photos —roads, trees, gulleys, rows of maguey, etc— to establish the limits of the segments and of the individual plots. The next step was to obtain the names of those who worked each plot during 1967. Anyone who operated any land in the segment —even though the majority of his land was outside of the segment— was included in the sampling frame. As the plots were identified, they were numbered chronologically and the names were listed on a separate sheet. These lists constituted the sampling frame for the second stage. The names of the farmers in each segment were the basic sampling units for second stage.

The size of the sample, for the first stage as well as the second, was calculated from information on corn yields from two sources:



1. Yields on fertilizer experiments carried out in the whole region in 1967. This information gave a measure of the variation existing between experiments. The number of segments to be included in the sample depended largely on the magnitude of this variation.

2) Objective yield measures taken in the fall of 1967 among a sample of traditional plantings in one part of the area. This permitted an estimate of the variation between farmers, from which the size of sample for the second stage could be determined. Based on these calculations, 12% of the total number of farmers on the lists were drawn in order to allow for refusals and yet assure a final sample of 10% of the farm operators in each segment. This gave a sample size with the necessary level of precision (251 farmers).

A random selection of the elements of the sample was carried out in the presence and with the participation of local officials, either of the *ejido* or of the *municipio.* The data were collected with an interview schedule drawn up after some experience in the area and pretested in December 1967. The majority of the interviews were done by students —principally from the National School of Agriculture— during the 6 week period from January 2 to February 15, 1968. The period covered in the questions relating to crop and livestock production was the calendar year 1967.

As the interviewing progressed, information that would be of immediate use to the coordinator in defining the strategy of the action program was passed on to him. When the field research was completed, the data were coded, tabulated and then processed at the Statistical Center of the Graduate College at Chapingo.

RESULTS OF THE BENCHMARK STUDY

The summary of results which was presented at the conference, is not included here as it is already available in *The Puebla Project 1967-69: Progress Report of a Program to Rapidly Increase Corn Yields on Small Holdings,* CIMMYT, Mexico, 1969. See pages 14-25 and 81-92, and the appendix tables in that report.

OBJECTIVE YIELD MEASUREMENTS

In order to have available a continuous measure of progress in raising corn yields, annual estimates are made in the field each year just before harvest time.

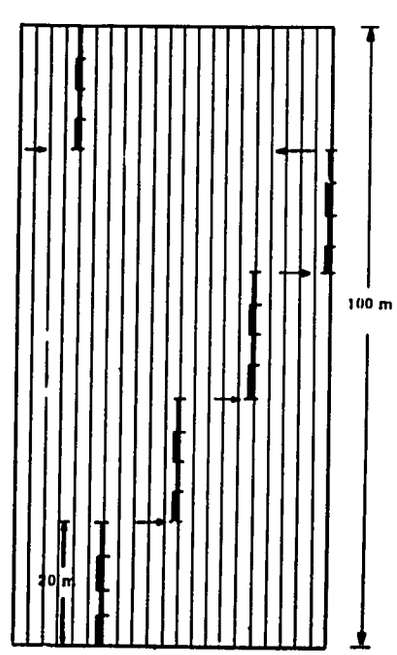
Two parallel approaches are being used to obtain a double check on progress: 1) a sample of high yield plots, compared to a general sample of the region, and 2) a yearly general sample of the area corrected each year for climatic variation to measure average progress on the entire area. During the early years the first approach will give the most accurate estimate, but when a high proportion of the farms are involved, heavier reliance will have to be placed on the second procedure.

For obvious reasons it was necessary to use sampling techniques; consequently, we will be dealing with yield estimates.

To make the general yield estimate for the area the first stage segments selected for the interview, were used again. Within these *segments,* a new sample of *parcels* was drawn. Then within these *parcels* a sample of *sites* was drawn. The sampling procedure within the parcels is shown in Figure 2.

These sampling procedures have been carried one step further through regression analysis and present estimates are based on measurements of ear length and diameter taken without husking or removing the ear from the plant.

In order to test this method, in 1968 it was necessary to take measurements of weight and moisture content as well as diameter and length of 20,000 individual corn ears. Based on analysis of this data on the computers of the Statistical Center of the Graduate College, a model was obtained for indirect estimation of yields. The use of this model, based on



length and diameter measurements, greatly facilitated the estimation of the 1969 crop*.

In 1968 the general sample of farmers was made up of 24 segments with 184 parcels and a total of 920 sites. The sample of high yield plots consisted of 16 localities with 123 lots and 615 sites.

Procedures and Results for 1969

For the 1969 harvest, both samples were enlarged so that the general sample included 34 segments with 216 parcels and 1085 sites. The sample of high yield plots included 55 localities with 370 lots and 1850 sites.

As was expected, the general sample included segments which were not completely traditional plantings, as the influence of the action program became evident over a broader area. The general sample was made up of 8 parcels in each segment and 5 sites in each parcel. Nevertheless, not all of the parcels were planted to corn and for this reason the total number of parcels is not a multiple of 8. Of the 272 segments, 216 or 79.4% were planted to corn.

For the high yield plots, a sample was taken at each locality in which there were farmers operating under supervision of the Puebla Project. Based on analysis of variance carried out on the data from the 1968 high yield plots a sampling rate of 20% was decided upon. In practice, 19% of the plantings were measured in three of the four zones and in the other zone, where the total number of plantings was small, 85% were sampled.

In carrying out the sampling, it was evident that not all of the farmers used the complete package of practices recommended by the project. This was most obvious in the case of the lower plant densities. Apparently, the uncertainty in regard to rainfall early in the season also influenced farmers to use somewhat less fertilizer which, again, influenced crop yields. Of course, it is probable that even though conditions had been optimum, not all of the participants would have followed completely the recommendations.

Actually, because of more favorable rainfall in the area reserved for expansion in 1970, referred to in the table as zone 5, the average yield of segments located in it was higher than those for the other zones, making an overall average of 1744 kilograms per hectare. The average yield for the sites located within the western two-thirds of the region, where the Project had concentrated its work up through 1969, was 1644 kilograms per hectare. This is the figure that will be used for comparing with the sample of high yield plantings in the same area.

TABLE 1. Average yields of grain at 12% moisture in the general area included in the Puebla Project, 1969.

No. Seg.	Location	No. of parcels with corn	Average yield kg/ha
1	San Francisco Tialoc	7	326
2	San Matías Tialancaleca	7	1241
3	Juárez Coronaco	5	1007
4	San Rafael Tianalapan	5	1759
6	San Baltasar Temaxcalac	7	5097
7	San Miguel Tianguistenco	8	2055
8	San Simón Atzizintla	8	760
9	Santa María Moyotzingo	4	1553
16	Santa María Moyotzingo	5	—
	Average yield for zone 1		1533
10	Santa Ana Xalmimilulco	6	3264
11	San Pedro Tlaltenango	6	1675
12	San Agustín Atzompa	6	1485
13	San Lorenzo Chiautzingo	7	3415
14	San Juan Pancoac	5	1450
24	Juan C. Bonilla	7	1413
39	Huejotzingo	5	520
	Average yield for zone 2		1889
15	San Andrés Calpan	8	1354
25	San Martín Tlamapa	8	2340
26	San Pedro Yancuitlalpan	7	1634
27	San Juan Tianguismanalco	8	719
38	San Buenaventura Nealtican	4	2067
	Average yield for zone 3		1623
17	Santa María Coronango	6	1117
18	San Lorenzo Almecatla	4	2169
19	San Matías Cocoyotla	4	1798
20	Santiago Momoxpan	5	2173
28	San Francisco Totimehuacan	5	1082
36	Guadalupe Hidalgo	8	712
37	San Juan Cuautlancingo	5	2331
	Average yield for zone 4		1626
29	Chachapa	7	2657
30	Tepatlaxco de Hidalgo	8	1811
31	Amozoc de Mota	8	2235
32	Sta. María Xonacatepec	8	2848
33	San Antonio Tlacamilco	7	1743
34	Acajete-Tepulco-Tepetzala	8	1365
	Average yield for zone 5		2110
	Overall average of sites		1744
	Overall average of sites for the first 4 zones where the Project had operated		1644

* For more information, see Heliodoro Díaz, Delbert T. Myren and Richard E Lund, "Estimating Corn Yields in the Puebla Area with a Regression Model Based on Ear Lenght and Diameter". This methodology will be studied further in the future to improve the level of precision.

This can be contrasted to the 2,809* kg/ha average yield obtained on the 19% random sample of fields planted by farmers involved directly in the Project. In spite of the fact that many of these participants did not follow the recommendations in their entirety, there was an improvement of more than 1,100 kg/ha.

Table 1 shows the yield estimates for 1969 by locality.

The variation in average yields by segments indicates that there were extreme situations in some localities where yields were minimum. In 6 of the 34 segments, average yields were less than one metric ton per hectare, including one case where the average of the 5 fields in corn was zero.

Table 2 gives the result for the high yield plots.

A second method for checking the progress in increasing yields was to compare the average yield obtained in 1969 (1644 kg/ha) with 1967 (1310 kg/ha) for the farmers in the general sample. This gives an average increase of 334 kg (28%). Taking into consideration that there was an increase of approximately 18% (236 kg/ha) attributable to climatic factors, the increase due to modifications in technology would be approximately 8% or 98 kg per hectare on the 60,000 hectares represented by the sample.

The 18% increase attributable to climate is estimated from the results obtained in experiments carried out by the agronomic research program in the Puebla Project area.

FUTURE EVALUATIONS

The sample survey carried out in January and February of 1968 will serve as a benchmark for future comparisons in order to measure progress at intermediate stages and at the completion of the project. Plans are now being formulated for an intermediate survey to be done after the 1971 harvest. These data will also serve as a new benchmark for future comparisons.

The evaluation program will continue to provide feed-back information to the coordinator of the program in respect to farmers' attitudes and level of participation of various institutions in the program.

* Calculated after adjusted the sampling rates of all zones to a common 19%; the overall average by sites without adjusting for over-sampling in zone 3 was 2,726 kg/ha and the unweighted average by zones was 2,765 kg/ha.

TABLE 2. Average yields of grain at 12% moisture on high yield plantings in the Puebla Project, 1969.

No.	Location	Average yield kg/ha
1	San Baltasar Temaxcalac	6365
2	San Martín Texmelucan	3095
3	San Jerónimo Tianguismanalco	6216
4	Ignacio M. Altamirano	1730
5	San Martinito	3415
6	San Rafael Ixtapalucan	3574
7	San Rafael Tlanalapa	3715
8	San Matías Tlalancaleca	2014
9	Juárez Coronaco	2124
10	San Juan Cuauhtémoc	3290
11	San Buenaventura Tecaltzingo	3350
12	Santiago Coltzingo	2042
13	Tlacotepec de José Manzo	3574
14	San Miguel Tianguistenco	3081
15	San Cristóbal Tepatlaxco	1768
16	Guadalupito "Las Dalias"	3375
17	San Andrés Hueyacatitla	4091
18	Guadalupe Zaragoza	2095
19	San Pedro Matamoros	2405
20	San Francisco Tepeyac	2256
21	San Felipe Teotlalcingo	2451
22	San Salvador El Verde	3920
23	San Lucas Atoyatenco	4956
	Average of 23 localities in zone 1	3256
1	Huejotzingo	2557
2	San Juan Pancoac	3096
3	San Miguel Tianguizolco	2703
4	Santa María Tianguistenco	2281
5	Colonia Chahuac	3039
6	San Luis Coyotzingo	4130
7	San Mateo Caputitlán	3620
8	Santa Ana Xalmimilulco	4713
9	San Simón Tlanicontla (D. Arenas)	3110
10	San Pedro Tlaltenango	3265
11	Juan C. Bonilla	2043
12	San Gabriel Ometoxtla	2646
13	San Lorenzo Chiautzingo	2920
14	San Juan Tetla	3055
15	San Nicolás Zecualacuayan	2303
16	San Antonio Tlatenco	2224
17	San Diego Buenavista	3260
18	Santa María Texcac	3102
	Average of 18 localities in zone 2	3004
1	San Andrés Calpan	2299
2	San Lucas Atzala	3167
3	San Pedro Yancuitlalpan	2729
6	Santa Isabel Cholula	1928
7	San Jerónimo Tecuanipan	3143
8	San Martín Tlamapa	3696
9	San Juan Tianguismanalco	1901
	Average of 7 localities in zone 3	2695
1	San Sebastián Tepalcatepec	1179
2	San Martín Zoquiapan	2573
3	Santa María Coronango	2660
4	San Juan Cuautlancingo	4440
5	San Lorenzo Almecatla	1855
6	Emiliano Zapata	1234
7	San Bernardino Chalchihuapan	795
	Average of 7 localities in zone 4	2105
	Overall average of sites: 2726 kg/ha	
	Overall average by zones: 2765 kg/ha	
	Weighted average by sites: 2809 kg/ha	
	Average of 55 localities: 2955 kg/ha	

A new aspect for the future will be the evaluation of high-lysine corn varieties as soon as these materials are available for distribution in the project area. The evaluation will include studies of farmer acceptance and effects on human and animal nutrition.

The intermediate survey to be conducted after the 1971 harvest will also measure a wide range of changes that have occurred both in agricultural practices and in the attitudes of people. Briefly, here are some of the concepts to be measured in the intermediate and final evaluations.

1. *Production Increases.* The new crop and livestock production data will be compared with the 1967 benchmark to determine the extent and geographical distribution of production increases. How much of the additional production is being used directly for food, how much for animal feed and how much for sales? To what extent does the additional production serve to increase family income, either through direct sales or sales of animals fed with the increased corn production?

2. *Changes in Amount and Sources of Family Income.* As on-farm income from all sources increases, does off-farm income drop, stay the same, or also increase?

3. *Use of Increased Income.* How much of the increased income is invested in land? How much is used for additional crop and livestock production? How much in different types of savings? How much for education of children? How much for different aspects of consumption? How much change is there in the family diet?

4. *Changes in Labor Use.* Is additional off-farm labor used to achieve the higher yields? Are labor needs of any part of the production process, reduced by mechanization? Does off-farm income in the area as a whole go down as a result of additional employment opportunities in agriculture? And many other questions related to labor use.

5. *Changes in Knowledge and Use of Recommended Technology.* The first question here is, to what extent has the farmer learned the reasons for and how to use a new package of improved practices —type of fertilizer, amount, when to apply, higher plant population, etc. In addition, we need to find out to what extent the farmer has broadened his decision-making abilities— to what extent he has become more of an entrepeneur in his thinking.

6. *Attitude Changes in General.* To what extent is there a change in the farmers' attitudes toward farming? Will increased production stimulate or slow down migration from the land? Is there any change in the farmers' attitudes to future education of their children and in their occupational aspirations for their children both inside and outside of agriculture. Is there any change in the alternatives they themselves are considering inside and outside of agriculture? Any change in attitude toward innovations in agriculture and in their general attitude of optimism or pessimism?

Another part of the evaluation will be related to the functioning of the agricultural infrastructure of the region, especially agricultural credit, crop insurance, the distribution of fertilizer and other inputs, and the marketing of crop and livestock products.

discussion

Q. Are you thinking to take another sample survey among the same farmers?

DIAZ. We plan to measure the same things in an intermediate survey to be carried out at the end of next year. We will try to measure the increase in production and how they are using this increased production —how much they are selling and how much for home consumption. We plan to find out what are they planning to do, and what they did, with the extra income as a result of the increased production. We are going to measure some of their attitudes toward the future, not only about the future education of their children, but also about their own plans. We will see to what extent the farmer is diversifying or plans to diversify his agriculture, or if he is planning to specialize in corn. We will ask about the other topics which I mentioned early.

GRANT. I wonder how important women are in this project, and what role they will play in the future. Are you going to do something about them? In his visit to El Salvador, Dr. Byrnes found some interesting things.

DIAZ. As I mentioned this morning, women are very important. For example, in credit, we had a situation where the men planned to

use it, but finally the women said "no". And the farmers didn't take the credit. The women participate actively in many farming activities, helping their husbands. In some cases, they go to plant with their husbands and I think this is an important thing to take into acount. The extension team has found that women attend each event, demonstrations, etc. However, I think that we should have a program for women.

Q. In regard to credit, what percentage of the credit came from private sources? What percentage from private banks?

DIAZ. You mean now or before? As I told you, 12% of the farmers had credit in 1967, but only 6.8% came from the official banks. Some of them used to get the money from private lenders.

WILLIAMS. Who are these private lenders?

DIAZ. In some cases the owner of a little store in the community and they lent some money to buy fertilizer, but charged a very high interest. There is a private lender in each community.

WILLIAMS. I would be very interesting to know, to estimate the interest charged to farmers in the area. As you know, only 12-15% of farmers in the country get credit from public sources. The rest get credit from private lenders, who charge as much as 1% per day.

Q. I would like to ask whether in the initial evaluation, the other income, besides that from corn, was also included.

DIAZ. Yes, this information is included in our papers.

HUBERMAN. This project has gone far enough so that you have some experience with demographic problems. As I understand, within the ejido system the land can not be sold nor further divided. The private plots, of course, can be divided if two or more sons decide to stay. This would mean that these already small plots will be dividad. And what happens with the migration from the farm? Are they going out?

DIAZ. We asked the farmers about the future of their children —what they would like their children to do. We also asked them a hypothetical question— what they would do if they received as much money as they usually earn in 10 years. The most common response was, "well I would like to continue working my land, but I would be concerned about the future and the education of my children". About two weeks ago, when a group of foreign visitors came to this community, the farmers asked these visitors: "What are you doing in your countries for the children? We are very worried here because this land cannot be divided any more. We need a better education for the children, and we are going to try to do that, but we do not know what the Mexican Government is doing for the children".

So, I think this is a very important question. They are concerned with trying to give their children a better education, because in the future these children will work, maybe in other activities. They wanted it when they were young, and now they are more and more aware of the advantages of education.

BYRNES. Do you have the feeling that by increasing production you are helping the farmer to stay on his land, and for his sons to stay on the land? Is the correct?

DIAZ. Well, we have had the opportunity to talk about that with some groups during this year. We asked them "how important is it for you to double your production?" And they told us: "The most important thing is that we are organized now and that we know how to get everything by working. Besides that, with the increase of production we can feed some animals and with this money we can send our children to school".

WILLIAMS. In relation to the women, her influence tends to be covert. We are working in an area with 6,000 people, 550 farmers. This community has no potable water, something the women in the area want more than anything else. In consequence, we designed a project in which shares were sold to women —a water company. Women decided that. We also organized a taxi company, through shares sold to people. Women took the initiative, since the community had no transportation for emergency cases, like going to see the doctor.

benefit-cost analysis of the puebla project

JAIRO CANO [1]
DELBERT T. MYREN [2]

THE ROLE OF ECONOMIC analysis in the evaluation of an investment project is to determine whether the project is justified in view of possible alternative uses of resources.

This paper presents an economic analysis of the first two years of operation of the Puebla Project in terms of its costs and benefits for the region, and then a projection of costs and benefits through 1975.

Analyses of costs and benefits are generally made in the planning phase, as part of the initial project, to determine or demonstrate its economic feasibility. Studies carried out in this manner are based on numerous assumptions in respect to behavior of the important variables. In cost-benefit analysis of agricultural projects it is essential to make suppositions about the behavior of farmers, production functions, prices and also the ecological environment. These suppositions are subject to levels of uncertainty which may cast serious doubt on the usefulness of this kind of study.

In spite of these shortcomings, there is a need for careful cost-benefit studies of investments in projects of technological change. This is especially true of projects focused on small holdings with little capital and low levels of education. There is a widespread belief that efforts such as the Puebla Project can be justified only in terms of humanitarian or political goals and not in terms of economic rates of return for the economy.

The present study examines what has occurred in the Puebla Project in terms of economic costs and returns for the region. It is based on reliable data collected as part of the evaluation work in the project. Suppositions have been avoided but when necessary care has been taken to adjust them as closely as possible to reality, insisting that they be conservative rather than optimistic. In calculating the benefits derived from the increase in corn yields, corrections have been made for the effect of climate.

METHODOLOGY

The methodology consisted of the following: separation of the various costs and benefits into categories, obtaining data, correcting for climate, and the calculation of coefficients to express the relation between benefits and costs.

Classification of Costs and Benefits

COSTS. In the analysis, two types of costs are identified: "direct" and "associated". The direct costs consist of the value of goods and services used for the establishment and functioning of the project during its operating life.

[1] Graduate Student in Communications, National School of Agriculture, Chapingo, Mexico.
[2] Head of the Communications Department, CIMMYT and Advisor in Evaluation for the Puebla Project.

Associated costs are those necessary to put into conditions for use or sale the goods and services produced by the Project. In the Puebla Project the direct costs are those which were necessary to produce valid information about corn production under rainfed conditions and to gain the use of this information by the farmer —that is, the costs of coordination, research, extension and evaluation. The associated costs are those entailed by the farmer in order to apply the new information in corn production.

BENEFITS. Two types of benefits are considered: primary and secondary.

The *primary* benefits are those goods and services, to which a monetary value can be assigned, that are produced as an immediate result of the activities of the Puebla Project or induced by it. These primary benefits have been separated into two groups: those that have been measured and those that have not. In this paper the benefits are calculated strictly in terms of the value of increased corn production on 60,000 hectares. This serves as a basis for calculating the net benefits attributable to the Project.

There is also a group of primary benefits not measured as yet, that should be pointed out. Among these are the possible cost reductions, in extending the new technology, that will become possible as the new knowledge and skills in corn production are absorbed by the farmers. Of equal importance will be the benefits derived from the organization of producers into groups, permitting greater efficiency in communication of knowledge and distribution of inputs, and better possibilities for certain kinds of joint action.

Although the primary reason for organizing groups is to facilitate teaching the farmer new methods and to help him adopt a "package of practices", the groups in fact also have a multiplier effect in diffusing information and enthusiasm about the Project, thereby greatly accelerating the process of change.

The *secondary* benefits are those in addition to the immediate goals and services of the Project. Once that farmers are organized, their group strength can be employed for more purposes. They may become aware of other problems that can not be solved individually but can be handled through common action. It is here that there may be benefits even greater that those derived from increased production.

The work of Project personnel also is aimed at developing decision-making capacity among individuals and groups; this is to assure that when the technical team withdraws from the area the farmers will be able to move ahead on their own. It is difficult to place a monetary value on these types of educational, social and political benefits; for this reason they are not included in an analysis of costs and benefits. However, the evaluation team is measuring and recording them in other terms.

Obtaining the Data

Direct Costs. The costs of coordination, research, extension and evaluation were obtained from the accounts of the International Maize and Wheat Improvement Center (CIMMYT).

Associated Costs. The increased production costs were calculated from case study data collected by the evaluation team. In addition, data were obtained on the fertilizer sales for high yield plots made by the fertilizer distributor "Agrónomos Unidos".

Direct Primary Benefits. Two sets of data, collected by the Evaluation team, were available for estimating yearly changes in corn production: 1) a general sample of the entire area, and 2) a sample of the high yield plots. Using these data two types of calculations are made: 1) a comparison of production on high yield plantings with that obtained on a general sample of the entire area, and 2) a measurement of year-by-year changes by comparing yield estimates from the yearly sampling of the entire area. In both cases the benchmark is the average yield in 1967 as measured by the evaluation team.

The first method is applicable when the number of high yield plantings is small and very little adoption of the new practices has occurred through imitation. As the number of high yield plantings grows and there is diffusion of information from farmer to farmer, it is no longer possible to identify all participants. Then it is necessary to turn to the second method.

In this study both methods are used: the first for 1968 and both for 1969. In 1968 the yields of most of the 143 plantings were measured by the evaluation team. For 1968, an average for high yield plantings was obtained by sampling approximately 19% of these plantings. A second estimate was obtained from a general sample of all corn plantings in the western two-thirds of the region —the area in which the project had been active up through 1969. This accounts for about 60,000 hectares of corn. Yields were estimated with a statistical model based on number of ears and measurements of length and diameter.

Correction for Climate

The following procedure was used to arrive at a correction for yearly differences in

climate. Yield data from identical experiments at different points in the region were compared for 1967, 1968 and 1969. These experiments included the same varieties, the same plant populations and the same fertilizer treatments. At the same time, a strong effort was made to give the same care in terms of timely control of weeds, land preparation, and so forth. In view of this, the assumption is made that the differences in yield from year to year are due basically to differences in climate, principally amount and distribution of rainfall. The main limitation of this procedure lies in the fact that the results of a small number of experiments, although well located, are generalized to a very wide area (60,000 has). The correction does not guarantee a high level of precision but is clearly preferable to making no correction.

Calculation of the Benefit-Cost Relationship

In this first economic analysis of the Project, the concern was with the joint productivity of factors and not the productivity of each factor by itself. For this reason, benefit-cost analysis was chosen.

The benefits and costs were first adjusted to 1967 as the base year, using a discount rate of 12%. This was done to make the quantities comparable. One hundred pesos of today cannot be compared directly to $100 pesos of 10 years ago. This adjustment was not made because of variations in the purchasing power of money but because each peso invested or earned is not idle but continues to generate interest which again generates more interest. Once the adjustment had been made in the cost streams as well as in the benefit streams, they were distributed in a uniform equivalent series for the number of years of operation considered, which in this case was of 8 years —from 1968 to 1975. The uniform equivalent benefits are thus made comparable to the uniform equivalent costs, and these two quantities are used to establish the benefit-cost relationship. If desired comparisons could also be made between present costs and benefits.

RESULTS

Direct Costs

The total direct costs are the total investment costs plus the annual operating costs. The data obtained from the accounting office of CIMMYT are summarized in Table 2 under the following categories.

a) *Salaries and perquisites.* This includes amounts paid to all technical personnel of the Project, payments to advisors and personnel contracted to carry out special projects, the costs of field and laboratory workers, the costs of others employees, the education tax, social security for all the personnel, life insurance and medical insurance for the technical personnel, and finally certain transportation costs, highway tolls that were not included in maintenance and operation costs.

b) *Field Operation and Laboratory.* This include laboratory materials, fertilizers, insecticides, fungicides, etc., used in the research program.

c) *Statistics.* This includes the development of the models for estimating yields and the value of data processing services provided free by the statistical laboratory at Chapingo.

d) *Vehicles.* This includes purchase costs, maintenance, repairs, gasoline, insurance, taxes and licenses for the vehicles of the project.

e) *Rental Costs.* This is an estimate of what it would cost to rent the offices of the project at the general agency for agriculture in the city of Puebla and the store rooms at Huejotzingo beginning in July, 1967 at a rate of US$480 per year for the offices and US$968 for the storerooms.

f) *General Costs.* These include payments for the mimeographed report in Spanish used at the annual meetings, a film for use in organizing groups of farmers, a projector, half the cost of the Spanish edition of the report. "The Puebla Project 1967-69" and other miscellaneous small costs. The cost of the Puebla report is not directly related to the field work of the project but may have some relation to the life of the project in the sense that it may have helped to obtain support from international funding agencies. In addition the international character of the report helped psychologically in gaining support for the project from national institutions.

g) *Overhead for services provided by CIMMYT.* The time dedicated to the Project by CIMMYT staff members, as advisors and participants in the fields of communications, soils, plant breeding and accounting, represents an additional cost that must be included. There is not an exact measurement for this cost, but following an accounting procedure used in CIMMYT it was assumed that a figure representing 30% of the total direct costs could be added to cover this in 1967 and that this would be reduced as the total budget of the Project expanded and as the direct role of CIMMYT staff was reduced so that in 1968

TABLE 1. Total investment in vehicles.

Year	No. used	Vehicles new	Remaining life		Purchase cost (US$)	Deductible value**	Cost of investment in vehicles
			No. vehicles	No. years			
1967	0	5			9671	0	9671
1968	5	1			2237	0	2237
1969	6	4			9660	0	9660
1970	10	7			17704	0	17704
1971	17	1			2237*	0	2237
1972	13	5	5	1	11530*	2306	9224
1973	17	1	1	2	2306*	922	1384
1974	14	4	4	3	9224*	5534	3690
1975	11	7	7	4	16142*	12908	3134

* To calculate the price of vehicles that will be purchased in future years, the average cost of those purchased up to now, was used. This average is US$2,306.

** On average a vehicle life of 5 years was used in the calculations and the amount of US$461 20 was deducted for each year of a vehicle use This amount was also used in estimating the residual value of the vehicles which would have less than five years of use at the end of the eight year period.

TABLE 2. Direct costs of the Puebla Project 1967-70 (US$).

	1967	1968	1969	1970
1. SALARIES AND PERQUISITES	13,271	50,228	88,564	111,785
2 FIELD OPERATIONS AND LABORATORY	4,344	12,195	8,005	10,779
3 STATISTICS				
a. Data processing		1,220	3,546	5,065*
b. Development of the model for estimating yields		326	1,519	
4 VEHICLES				
a. Purchase	9,671	2,237	9,660	17,704
b. Maintenance and operation	2,305	11,550	16,578	24,495
5. RENT ESTIMATES				
a. Offices in Puebla	240	480	480	480
b Store rooms in Huejotzingo	720	968	968	968
6 GENERAL EXPENSES				
a Mimeographed report for annual meeting		80	486	542
b. Visual aids			2,376	
c. Projector			680	
d Report "The Puebla Project 1967-69"			2,500	
e. Miscellaneous	679	586	237	173
	31,230	79,870	135,599	171,991
7 OVERHEAD FOR SERVICES PROVIDED BY CIMMYT**	9,369	19,968	27,120	30,958
TOTAL DIRECT COSTS	40,599	99,838	162,719	20[illegible] 949

* Item 3a for 1970 was estimated at the same value as 3a + 3b for 1969.

** Following a CIMMYT accounting practice for assigning overhead to various projects, a percentage of the total costs of the Puebla Project was added each year for CIMMYT overhead· 30% for 1967, 25% for 1968, 20% for 1969 and 18% for 1970

this would amount to 25% and in 1969 to 20%.

Data for these groups of costs were obtained for 1967, 1968, 1969 and up through June, 1970. The costs for the rest of 1970 are estimated taking as a basis the amount budgeted for the year.

The costs for the years 1971 through 1975 are calculated using 1970 as a base, under the supposition that the costs of the Project had neared their maximum level in 1970. The estimated costs for 1971 include an additional communicator and the purchase of one more vehicle. From 1971 to 1975 an increase in costs of 6% per year was assumed based largely on salary increases. The vehicles to be purchased in these years are to replace those that will have completed 5 years of service. A gradual reduction in CIMMYT overhead is assumed with the following percentages of total costs added for this concept: 16% in 1971, 14% in 1972, 12% in 1973, 10% in 1974 and 8% in 1975. Table 3 gives the resulting cost projections for

TABLE 3. Direct costs of the Puebla Project, calculated for 1971-75.

	1971	1972	1973	1974	1975
1. Basic costs *	182,310	201,189	223,038	237,887	256,072
2. Salary of one person in communications	5,252				
3. Vehicles	2,237	9,224	1,384	3,690	3,134
	189,799	210,413	224,422	241,577	259,206
4. Overhead for services provided by CIMMYT**	30,368	29,458	26,931	24,158	20,736
	220,167	239,871	251,353	265,735	279,942

* The basic costs for 1971-75 were calculated using a base these of 1970, as it is supposed that the yearly costs of the Project are now near the maximum level In 1971 the staff will be increased by one person in communications and one more vehicle will be added. From 1971-1975 a cost increase of 6% per year is estimated, largely for salary adjustments The vehicles to be purchased are to replace those that have completed 5 years of service

** The following percentages were used 16% in 1971, 14% in 1972, 12% in 1973, 10% in 1974 and 8% in 1975

the costs being projected are only those of 1971 to 1975. It should pointed out here that the corn program and only for the area defined in 1967. It is possible that in the future the project may be expanded to work with other crops or livestock and that the area may be enlarged. This would modify the relationship between benefits and costs.

The components of direct costs, for purposes of analysis, are the total investments costs and the current operating costs, which are presented in Table 4.

The total investment costs include the 1967 costs for development of a general methodology, the selection of the work area, the definition of strategies, the evaluation study to establish a benchmark and the initial agronomic research. It also includes the total investment in vehicle purchase from 1967 to 1975, the purchase of a projector and the production of an agricultural film to be used in organizing groups in the area, 50% of the costs of the Spanish edition of "The Puebla Project 1967-69" and finally the development of the model for estimating yields.

The current operating costs include all of the other costs that have been incurred year by year as a result of the activities carried out by the Project in the program to increase corn yields.

The current operating costs and the total investment costs represent expenditures made in different periods and for this reason are not comparable. One way to convert them to comparable units is to adjust all costs to the same base period. For this purpose 1967 was chosen because much of the investment was incurred at that time. The procedure consists in applying a rate of 12% to the different periods and

TABLE 4. Direct costs of the Puebla Project, 1967-1975 (US$).

	COST	Cost to 1967 * adjusted
I INVESTMENT COSTS		
A. Development of the general methodology, selection of the area, defining the strategy and establishing the bench mark (from Table 2 1 + 2 + 4b + 5 — 6 + 7, in 1967)	30,928	30,928
B Purchase of vehicles		
1967	9,671	9,671
1968	2,237	1,997
1969	9,660	7,701
1970	17,704	12,601
1971	2,237	1,422
1972	9,224	5,234
1973	1,384	701
1974	3,690	1,669
1975	3,134	1,266
C Visual aids and projector (1969)	3,056	2,436
D. Report "The Puebla Project 1967-69" (1969)	2,500	1,993
E Development of the model for estimating yields		
1968	326	291
1969	1,519	1,211
INVESTMENT COSTS ADJUSTED TO 1967		79,121
II CURRENT COSTS		
1968	97,275	86,853
1969	145,984	116,378
1970	185,245	131,854
1971	220,167	139,920
1972	239,871	136,109
1973	251,353	127,343
1974	265,735	120,205
1975	279,942	113,063
TOTAL COSTS OF OPERATION AND MAINTENANCE ADJUSTED TO 1967		971,725

* To adjust the costs a discount rate of 12% was used.

different quantities involved through the financial equivalence

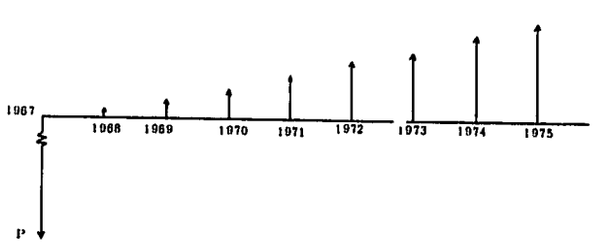
$$P = \frac{S}{(1+i)^n}$$

in which P is the present value of the quantity S, discounted at the interest rate i during n periods. The result of the adjustment are presented in the second column of Table 4.

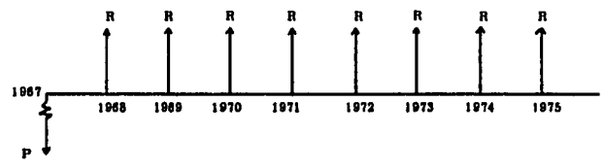
If we had data on the benefits for the 8 years of operation of the project, we would be able to compare the total of net benefits discounted to the year 1967 with the total direct costs based on the same year. However, we have real data for only two years of operation —1968 and 1969. This makes it necessary to calculate uniform equivalent costs for any year of operation. To do this a discount rate of 12% is applied through the financial equivalence

$$R = P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$$

This equivalence is a mathematical instrument useful for distributing uniformly a sum in various periods. It would not be correct to distribute this arithmetically because the general economic system of a country assumes that the capital goods are never idle that the surplus from one period is invested in the next, and consequently ears an interest. What happens is shown graphically below where P is the initial sum which, when distributeo,



in a serios of periods continues to generate interest. This is a phenomenon of geometric growth that can be distributed uniformly among periods through the equation noted and then gives the graphic shown below.



In this way the uniform equivalent cost was obtained for the total investment costs and the operating costs for the 8 years of activity calculated for the Puebla Project.

The results were:

Uniform equivalent of the total investment costs	US$ 15,927
Uniform equivalent for current operating costs	US$195,611
Total uniform equivalent costs	US$211,538

Associated Costs

The associated costs, as defined in the chapter on methodology, are costs incurred by the farmer in applying new information in corn production. In the case of the Puebla Project these costs include basically the cost of fertilizer, plus transportation and interest payments, and the cost of using greater quantities of labor, animal power and tools. For purposes of the benefit-cost-analysis presented here, only the costs of fertilizer, transport and interest payments are included. The greater use of labor, animal power and tools was considered without cost in economic terms and at regional level. That is, this does not represent an economic cost at the regional level It is an effort of the farmers themselves and the neighbors with their own animals and equipment and using time in which they otherwise would be unoccupied As the analysis is for the region it is considered correct to include as associated costs only those for fertilizer, transport and interest because these are the only out-of-pocket payments that really leave the region. The results of more intensive use of present labor and capital represent a direct benefit attributable to the Puebla Project.

The calculation of associated costs for 1968 was made from data obtained by the evaluation and extension teams among tradi-

tional farmers who also had high yield plots. This study, published on page 92 of "The Puebla Project 1967-69" shows an increase in cost as a result of greater use of fertilizer of US$39.78 per hectare. This calculation is based on an average cost of fertilizer for the high yield plots of US$62.88 and an average expenditure for fertilizer of US$23.10 by traditional farmers. The extension team provided a list of the 143 high yield plots with a total of 76 hectares, planted by farmers who applied the new technology during 1968. As the extension activities of the project were first initiated in 1968 it is not reasonable to expect an impact of the recommendations outside of the 76 hectares. Calculated in this way, the total associated costs for 1968 amounted to US $3,024 (Table 5).

For 1969 the calculations are based on data obtained from the fertilizer distributor "Agrónomos Unidos" which distributed fertilizer for 2,625 hectares of high yield plantings. The total cost was US$152,114. In addition, it is known that in 1969 a total of 2,975 hectares were operated following in general the recommendations of the project, under credit provided the official agricultural banks. However, it was not possible to obtain the data on the value of fertilizer applied nor the lists of those who participated in order to go into the field and make objective yield measurements of the harvest. For this reason it was assumed that the part of the increase of the 60,000 hectares that was not explained by the measured increase on the 2625 hectares, took place on the 2975 hectares.

This supposition tends to over estimate the costs because it is probable that the rates of fertilization were somewhat less than those recommended. However, the results were as follows. There was a remaining increase of 2,783.5 tons not explained by the 2,625 hectares of high yield plots. This increase could have been obtained on 2,359 ha (2,783.5 ton ÷ 1,180 ton/ha = 2,359 ha). The average cost per hectare fertilized was US$59.72 on the high yield plantings. Therefore with these 2,359 hectares the cost for fertilizer would be US$136,633 (2359 ha x US$59.72/ha = US $136,633). On the other hand, the fertilizer that would have been applied on 4,984 hectares (2625 — 2359) following traditional methods would have been US$115,130 (4984 ha x US $23.10 = 115,130). With these calculations a figure was arrived at of US$173,617 for the associated costs for 1969 (152,114 + 136,633 — 115,130 = 173,617).

TABLE 5. Costs associated with the benefits in 1968 and 1969.

	US$
1968	
Cost of fertilizer applied according to the recommendations of the Puebla Project on 76 ha*	4,779
Cost of fertilizer that would have been applied if traditional methods in the zone had been followed**	1,755
Cost associated with the benefits in 1968	3,024
1969	
Cost of fertilizer applied on 2,625 hectares of high yield plantings***	152,114
Cost of fertilizer applied by farmers who operated with credit of the official banks and by farmers who adopted the new technology, but for which specific data is not available****	136,633
Total	288,747
Cost of fertilizer that would have been applied on 4,984 ha (2625 + 2359) if traditional methods had been followed	115,130
Costs associated with the benefits in 1969	173,617

* The average cost per hectare is 786 pesos (US$62 88) including interest payments and transport. Data taken from a study of production costs done by the Evaluation Program in 1968

** 320 kg/ha of 10-8-4 at 742 pesos including transportation; that is 261 pesos plus 27 80 in interest charges or a total of 288 80 pesos (US$23 10)

*** Data obtained from the sales records of the private fertilizer distributor Agrónomos Unidos

**** It was assumed that increases not explained by the production of the high yield plots supervised directly by Project personnel an addition 2359 hectares fertilized according to recommendations of the Project (2783 5 ton — 1,180 ton/ha = 2359 ha) The average per hectare cost of fertilizer for the high yield plots (US$57 92) was also used in making the calculations for this area

Primary Benefits

Primary Benefits for 1968. As mentioned before, in the first year the impact of the program reached only those who were directly involved in carrying out high yield plantings. In this way 76 hectares produced a total of 272,817 kg of corn. This information was obtained by taking measurements directly in the fields of participating farmers and was verified by weighing the production of most of the individual plots. The expected production on these 76 hectares based on the average yields for 1967 (1310 kg/ha) was 76 ha x 1310 kg/ha = 99,560 kg. Accordingly the increased increased production achieved in 1968 on the 76 hectares was 173,257 kg. However, this increase cannot be attributable completely to the project because it includes a climate effect

—notably more favorable in 1968 than in 1967 — for which a correction will be made later.

Primary Benefits in 1969. In the second year the Puebla Project directly affected 5,000 hectares of which 2,625 were cultivated as high yield plantings by 1521 farmers and the other 2975 were operated with credit of the official banks.

The 2625 hectares of high yield plantings were distributed in 56 communities belonging to 21 municipios in the following form: 24 communities in Zone 1, 16 in Zone 2, 9 in Zone 3, and 7 in Zone 4. These were distributed in all of the western portion of the Puebla Project area and in this way the Project had some influence on the 60,000 hectares of this part of the area.

At the harvest time a general area sample was taken to represent both traditional and high yield plantings on these 60,000 hectares of corn. The sample consisted of 173 corn fields. In these parcels 75,000 ear measurements of length and diameter were made as well as measurements of the number of ears per unit area. All of these data were processed by the statistical center at the Graduate College in Chapingo using the model developed for estimating yields The information obtained in this way gave an estimated average yield on the 60,000 hectares of 1644 kg of corn per hectare for 1969.

In comparing this yield with that for 1967 (1310 kg per hectare) the net increase is 334 kg/ha before correcting for the climate effect.

Correction for Climate. The reasons for making a climate correction have already been explained and the results for 1968 are published in "The Puebla Project 1967-69", page 88. The results for four levels of nitrogen and phosphorus and different plant populations gave percentage yield increases in respect to 1967 attributable to climate of 48.2%, 55%, 57.9% and 55.1%. As a correction factor for climate effect for 1968 the average of the four was taken —54%. The treatments covered a range including both the traditional level and the recommendations of the Puebla Project so that the soils specialist could draw a response curve to cover expected yields for the treatment recommended by the project as well as for the average treatment being used in the region at the time of initiating the project.

For 1969 the number of experimental sites was reduced because the additional experience gained in the meantime by the soils department. In this way it was possible to carry out more complex trials on fewer sites. Based on this work two production functions were used for making the climate corrections for 1969 —the parcels located at San Pedro Tlaltenango (Zone 2) and at San Andrés Calpan (Zone 3). The equations with the corresponding calculations are presented here:

I LLANO GRANDE (San Andres Calpan)

$$Y = 1967.78 - 16.722\,(N\,50) - 27\,6841\,(P_2O_5) - 8.7821\,(D\text{-}30) - 0\,0866\,(N\text{-}50)^2 - 0\,0791\,(P_2O_5)^2 - 0\,3612\,(D\text{-}30)^2 - 0\,0457\,(N\text{-}50)\,(P_2O_5) - 0\,1553\,(N\text{-}50)\,(D\text{-}30) - 0\,0484\,(P_2O_5)\,(D\text{-}30)$$

II. SAN PEDRO TLALTENANGO

$$Y = 2212\,51 - 36\,0704\,(N\text{-}50) - 1\,9625\,(P_2O_5) - 21.7118\,(D\text{-}30) - 0.1183\,(N\text{-}50)^2 - 0\,0021\,(P_2O_5) - 0\,4391\,(D\text{-}30)^2 - 0\,0227\,(N\,50)\,(P_2O_5) - 0\,1203\,(N\text{-}50)\,(D\text{-}30) - 0\,0716\,(P_2O_5)\,(D\text{-}30)$$

34-17-50M	
Average 1967 (8 locations)	1540.3
Average 1969 (2 locations)	1793.3
Average attributable to climate	253 0
% of increase attributable to climate	16 4%
100-50-50M	
Average 1967 (8 locations)	3147 5
Average 1969 (2 locations)	3975.7
% of increase attributable to climate	26.3%
130-40-50M	
Average 1967 (8 locations)	3618.8
Average 1969 (2 locations)	4366.0
Increase attributable to climate	747.2
% of increase attributable to climate	20.6%
200-20-20M	
Average 1967 (8 locations)	4375.0
Average 1969 (2 locations)	4815.4
Increase attributable to climate	404 4
% of increase attributable to climate	10.1%

% average attributable to climate

16 4 — 26 3 — 20 6 — 10 1 = 73 4 — 4 = 18.3

Correction for climate 18%

It should be noted that the increases are expressed as percentages of the estimated yield for the region in 1967 (1310 kg/ha).

Primary Benefits Attributed to the Project. These results are presented in Table 6. For 1968 the expected production on 76 hectares if the new technology had not been used, is 153,322 kg of corn. In comparing this figure with the 272,817 kg that were in reality obtained it is possible to isolate production increase attributable to the Puebla Project of 119,495 kg.

For 1969 there is a yield increase of 334 kg/ha for the 60,000 hectares sampled. In applying the correction for climate (18%) it was found that an increase of 236 kg/ha (1310 x .18 = 236) would be due just to the climate effect. The final result of these calculations is to isolate an increase in average yield attrib-

utable to the Puebla Project of 98 kg/ha (334 — 236 = 98). For the 60,000 hectares influenced by the Puebla Project in 1969 these 98 kilos represent an increase in production of 5,580 tons of corn (60,000 ha x 98 kg/ha = 5,880,000 kg).

Value of the Increased Production. To place a value on the increased production, the guarantee price for corn of US$75.20 established by the official Mexican institution CONASUPO was used. According to observations made by the extension team, prices in the region were somewhat higher in 1969-70 but this figure was chosen to avoid any possible overevaluation of the benefits. Table 6 shows the value of the increase on production for 1968 at US $89.86 and the value for 1969 at US$442,176.

TABLE 6. Primary benefits attributable to the Puebla Project in 1968 and 1969.

1968		
I	Corn produced on 76 ha	272,817 kg
II	Expected production based on average yields in 1967 (1310 kg/ha x 76 ha)	99,560 kg
III.	Expected increase due to climate (1310 kg/ha 54 x 76 ha)	53,762 kg
IV	Expected production with traditional methods (II + III)	153,322 kg
V	Increased production attributable to the Puebla Project (I-IV)	119,495 kg
VI	Value of the additional production attributable to the Puebla Project*	US$ 8,986
1969		
I.	Average yield for 60,000 as estimated by the statistical sample	1,644 kg/ha
II	Expected yield, based on 1967	1,310 kg/ha
III.	Expected increase due to climate (1310 kg/ha x .18)	236 kg/ha
IV	Expected yield with traditional methods (II + III)	1,546 kg/ha
V	Average yield increase for 60,000 ha, attributable to the Puebla Project (I — IV)	98 kg/ha
VI.	Production increase attributable to the Puebla Project (60,000 ha x 98 kg/ha)	5,880 tons
VII.	Value of the increased production attributable to the Puebla Project*	US$442,176

* Based on the CONASUPO guarantee price of 940 pesos per ton (US$75 20)

Net Primary Benefits

The net primary benefits are the result of substracting the costs of production from the primary benefits. These operations and the results are shown in Table 7. In 1968 the primary benefits attributable to the Puebla Project were US$8,986 and the associated costs US$3,024. As a result, the net primary benefits were US$5,972.

In 1969 the respective figures were US $442,176 for the benefits and US$173,617 for the costs. The resulting net primary benefits were US$268,559.

TABLE 7. Net primary benefits attributable to the Puebla Project in 1968 and 1969.

	US$
1968	
Primary benefits attributable to the Puebla Project in 1968	8,966
Cost associated with the primary benefits in 1968	3,024
Net primary benefits	5,962
1969	
Primary benefits attributable to the Puebla Project in 1969	442,176
Costs associated with the primary benefits in 1969	173,617
Net primary benefits for 1969	268,559

Benefit Cost-relation

In order to adjust the benefits to a certain year and then distributed them in uniform equivalent quantities among the number of periods in which they were produced, a discount rate of 12% was used; the same financial equivalences were used as in the case of the costs.

The second column of Table 8 gives the net primary benefits adjusted to 1967. The sum of the two years adjusted to 1967 is 5,323 + 214,094 = 219,417.

The costs adjusted to 1967 of the 1968 and 1969 costs are also presented in Table 8, the total being US$235,085. The coefficient resulting from dividing the net primary benefits adjusted to 1967 by the adjusted direct costs expresses the benefit-cost relationship for the first two years of operation. The coefficient

TABLE 8. Benefit-cost relationship for the Puebla Project, calculated for two years of operation.

	US$	Adjusted to 1967 (I = 12%)
1 Net primary benefits		
a. In 1968	5,962	5,323
b. In 1969	268,559	214,094
NET PRIMARY BENEFITS ADJUSTED TO 1967		219,417
2. Uniform equivalent costs of the fixed investment for the two years (15,927 x 2 = 31,854)		31,854
3. Costs adjusted to 1967 of current 1968 and 1969 costs (86,853 + 116,378 = 203,231) — (see Table 4)		203,231
4 Adjusted costs, in 1967, of total 1968 and and 1969 costs		235,085
Cost benefit relationship for the first two years of operation: $\frac{B}{C} = \frac{219,417}{235,085} = .93$		

in this case is .93, which means that the benefits are almost equal to the costs.

Table 9 presents individual benefit-cost relationships for 1968 and 1969 in order to show the rapidity with which this relation has improved. In this case the benefits and costs are for individual years and it is not necessary to adjust them to a constant base. What was done in this case was to add to the costs of each year, a uniform equivalent for the investment costs. The total costs obtained in this way for 1968 and 1969 are respectively, US$113,202 and US$161,911.

TABLE 9. Benefit-cost relationship, year by year.

	1968	1969
1. Net Benefit	5,962	268,559
2 Current costs (from Table 4)	97,275	145,984
3. Uniform equivalent investment cost	15,927	15,927
4. Benefit-Cost Relation	$\frac{5,962}{113,202} = .05$	$\frac{268,559}{161,911} = 1.66$

The resulting cost-benefit coefficients are .05 for 1968 and 1.66 for 1969.

Benefits for the Farmer

Up to here we have been concerned with benefits and costs at the regional level, an important issue in deciding on the economic desirability of a public investment. However, in studying the results of the Project it is also necessary to look at the benefits derived by the individual farmer. These benefits are an important incentive for the farmer who decides to participate actively in a project of technological change The financial benefits for the farmer are obtained by comparing the increase in production costs as a result of adopting a new technology with the increase in the value of the production from his parcel. The question of benefits at the farm level deserves a separate paper. However, it is worth noting briefly some figures relative to benefits for the farmer. The value of the increased production, corrected for climate effects is the most concrete benefit that can be quantified. The increase in costs is determined by the price and additional quantities of inputs, and is expressed here as associated costs.

The relation between benefits, corrected for climate, and associated costs is a general indicator of what a farmer receives on the average for each peso invested in the application of new technology. Taking data for 1968 from Tables 5 and 6, we find a relationship of 2.97 (8,986 ÷ 3,024) = 2.97 and for 1969 a relationship of 2.55 (442,176 ÷ 173,617 = 2.55). One possible explanation for the higher coefficient in 1968 may be that because of the small number of the plots, the extension personnel were able to give more intensive supervision to each of them.

PROJECTIONS BASED ON THE RESULTS OBTAINED DURING THE FIRST TWO YEARS OF OPERATION

To visualize what may be expected to occur over a period of 8 years of operation, a projection has been made of benefits and associated costs. This procedure is commonly used in feasibility studies and in this case the data and experience provide a reasonable basis for projecting ahead to 1975. Although the data presented here, with the exception of those for 1968 and 1969, are assumptions, every effort has been made to project not only from past data but also to take into account the experience of the technicians involved. The suppositions on which these projections are based are as follows:

1. The cost of fertilizer and the price of corn remain constant during the next five years.
2. In 1970 and 1971 the high yield plantings will give the same yield increase as in 1969, namely 1180 kg/ha more than that obtained on traditional plantings in 1967.
3. In 1972 and 1973 a new hybrid or open pollinated variety will be used extensively in the region and will give an average yield increase of 10% over the high yield plantings in 1969 (2,726 x 0.1 = 2,999 kg/ha). The yield increase will then be 1453 kg/ha (2,999 — 1,546 = 1453).
4. The price of improved seed will be the same as that presently charged for a hybrid by the National Seed Producer (3 pesos per kilo or US$.24).
5. In 1974 and 1975 the second improved variety will come into general use in the Project and it will permit an additional yield increase of 5% over the 2999 kg/ha from the variety used in 1973, or 150 kg more, for a total yield increase of 1603 kg/ha on the high yield plantings (1453 + 150).
6. A total of 80% of the area will be planted with high yield technology in 1975 based on a total estimated corn area in the

region of 80,000 ha. This will mean 64,000 hectares under high yield plantings.

7. The organization of groups of farmers and other work of the extension team will permit increasing the area in high yield plantings at the rate shown in Table 10.

TABLE 10. Cost-benefit analysis for 8 years of operation of the Puebla Project.

Year	High yield planting (ha)	Yield increase (kg/ha)	Increase in production (ton)
1970	12,496*	1,180	14,745
1971	20,000	1,180	23,600
1972	35,000	1,453	50,855
1973	50,000	1,453	72,650
1974	60,000	1,603	96,180
1975	64,000	1,603	102,592

ASSOCIATED COSTS CALCULATED FOR 1970-1975

Year	High yield planting (kg/ah)	Increased costs for fertilizer (US$39.78/ha)	Increased costs for seed (US$3.20/ha)
1970	12,496	122,211	
1971	20,000	795,600	
1972	35,000	1,392,000	112,000
1973	50,000	1,989,000	160,000
1974	60,000	2,386,800	192,000
1975	64,000	2,545,920	204,800

NET BENEFITS CALCULATED FOR 1970-1975

1970	1,108,824	497,091	611,733
1971	1,774,720	795,600	979,120
1972	3,824,296	1,504,000	2,320,296
1973	5,463,380	2,149,000	3,314,380
1974	7,232,736	2,578,000	4,654,736
1975	7,714,918	2,750,720	4,964,198

NET BENEFITS ADJUSTED TO 1967 (US$)

	(i = 12%)		
1970	435,432	BENEFIT-COST RATIO	$= \frac{8,174,208}{1,050,846} = 7.8$
1971	621,231		
1972	1,316,536		
1973	1,678,065	BENEFIT-COST RATIO	$= \frac{1,645,491}{211,538} = 7.8$
1974	2,106,904		
1975	2,015,040		
TOTAL	8,174,208		

8. To calculate associated costs it was supposed that the increased cost for fertilization was US$39.78 per hectare as shown earlier in the production study carried out by the evaluation team. In addition, the increased costs include US$3.20 per hectare for planting with the new corn variety produced in the project area. This figure is based on the farmer employing 20 kg/ha of seed and selling an equivalent amount of his own seed at the market price of one peso or US$.08 per kilo [20 (.24 — .08) = US$3.20].

Table 10 shows the manner of arriving at the benefit-cost relation for 8 years of operation of the Project. To calculate the benefits, corn was valued at the present support price of US$75.20 per ton. From these benefits the associated costs were subtracted to obtain the net benefits expected for the next six years of operation of the Project. These benefits were adjusted to a 1967 base, giving a value for that year of US$8,174,208. The total direct costs, composed of the total investment costs plus the current operating costs, both adjusted to 1967. These data were presented in Table 4, and amount in total to 79,121 + 971,725 = US $1,050,846.

The benefit-cost relation can be obtained by comparing the adjusted values of the net benefits and direct costs, or through a comparison of the uniform equivalent benefits with the uniform equivalent costs. In Table 10 both calculations are made and give the same coefficient of 7.8.

FINAL COMMENTS

Benefit-cost relationships are not criteria as such, but rather may contribute to form criteria for investment. There is no simple mechanical test for determining whether the benefits are sufficient to merit carrying out a project. Risk and uncertainty abound and professional criteria and common sense can not be replaced by an equation. To arrive at reasonable conclusions in evaluating a project, it is necessary to look at every thing that is known about all aspects of it and all important interrelationships. What may appear to be a decisive factor in one case may be of little importance in another. For these reasons, instead of an interpretation of results, we have decided to make a few final comments about relevant aspects of the paper presented.

In the first place we wish to insist that expected increases in yield are probably the most important factors of uncertainty in looking at agricultural projects. The uncertainty comes not only from the presence in the ecological environment of uncontrollable factors such as climate but also from factors related to the decisions of the farmers themselves. In this particular project the knowledge exists or is being produced with which it will be possible for farmers to increase yields in spectacular manner, but it is not possible to exclude the possibility of an unfavorable reaction for psychological, political or social reasons or because of deficiencies in rural infrastructure.

There is also still much to be learned about the ways in which risk can be incorporated into a systematic scheme for calculating yields over a period of years.

In respect to financial aspects, these do not exist for the Puebla Project as the goods and services produced do not yield a return to the Project as such. What the Project produces is information and technical assistance; no attempt is made to sell either. In fact, it is doubtful, at least at this early stage, that the farmers would be willing to pay for the technical assistance provided.

For this reason the question of whether the Puebla Project is profitable has no answer if we look only at the internal financial aspects —that is whether the project pays for itself. There is no procedure for the Project itself to capture the returns. Nor does the product that the Puebla Project has to offer to the consumers, have a physical body.

To be sure the information is useful but the fact that it can be applied in unlimited quantities once that it is disseminated makes it difficult or impossible to fix a price. Perhaps this is a reason that information and technical assistance have been undervalued and at times completely omitted.

Herman Van der Taak, of the Economics Department of the International Bank for Reconstruction and Development has referred to the almost complete omission in the evaluation of agricultural projects of the costs and benefits attributable to the generation and dissemination of agricultural knowledge. Van der Taak summarizes the situation in these words "the returns to investments in irrigation projects and colonization programs appear to be greater than they are in reality while the returns may be much higher from improvements in agricultural methods without great capital investments.

The economic rate of return to the Puebla Project would appear to place it in the category of desirable public investments.

philosophy and operating principles for programs to increase agricultural production in areas of small holdings

LEOBARDO JIMENEZ S.[1]

THE PURPOSE OF this presentation is to analize some of the experiences of the Puebla Project in order to: 1) define certain philosophical positions for programs of this type, and 2) establish basic principles for the operation of programs faced with similar problems.

First, let's explain what we mean by "areas of small holdings". We have in mind geographic zones in which the population, through its involvement in agriculture as a fundamental activity of subsistence, has exerted strong pressure on the land leading to an extreme subdivision of this resource. At present this condition signifies low levels of living for those who farm the land.

The philosophy of the Puebla Project rests on the premise that man is the motive and the end of all creative activity. This implies that man is the focal reservoir of the values, the moral vitality and the intellectual and physical capabilities to solve the problems imposed by the physical and social environment in which he lives. It also implies that certain members of society are faced with fundamental problems which can only be solved by an organized effort over and beyond that of the individual. In this manner, the definition of the problems on one hand, and their solution on the other, gradually strengthens the capacity of the less-favored members of society to solve their own problems.

Within this framework of ideas, some of the experiences of the Puebla Project will be analyzed. The experiences presented will be related to: 1) social processes in agricultural programs, 2) criteria for organizing and coordinating programs, and 3) considerations in the establishment of programs for attaining rapid increases in production.

SOCIAL PROCESSES IN AGRICULTURAL PROGRAMS

A process should be understood as the summation of successive phases and their interrelationships, which determine a phenomenon. Following this concept, the Puebla Project should be understood as a sequence of phases. These phases, in turn, constitute interdependent processes which must be understood in terms of the operation of a program which seeks to change a typically subsistence agriculture to a commercial one. Let us look at this phenomenon schematically, based on observations made in the Puebla area.

To begin with we must accept that to understand the process the present situation is only partially helpful since the present Puebla

[1] Researcher-Professor, Graduate College, National School of Agriculture, Chapingo, Mexico.

Project is but a stage in the process of change, and a result of previous phases. For this reason it will be more productive to examine the phases of the process. This analysis will be made on the assumption that there are three fundamental human components which are responsible for the agricultural transformation being sought: the producers, the public and private institutions rendering agricultural services, and the technical staff. The phases are outlined as follows:

First Phase

In this phase we concentrate our attention on the agricultural population of the area. The farmer has within his culture the necessity of producing maize since this is the basic food for him and his family and for whatever livestock he has. The important aspects of this phase may be summarized in the following manner:

1. The agricultural activity is wholly a family affair. The members of the family participate directly in the process of production and in many decisions. The father must produce what is needed for the maintenance of the family. The mother has to help in the production of the crop and administers its use according to the needs of the family. However, the father has the *responsibility* for organizing his work along with that of his family.

2. In the case of corn, the farmer, through a cultural process of socialization, learns from his father how and when to plant. That is, he receives from his parents "a technological package" which applied to the production of the crop enables him to obtain certain levels of production for his needs. In this way, the farmer gradually learns the ecological conditions of his environment and its relationship to what he produces.

3. On the other hand, his family grows and his offspring have children, while at the same time continuous cropping through the centuries, decreases the fertility of the soils. This lower fertility is reflected in a reduction in crop yields. To respond to this situation the farmer develops various mechanisms. If he has other fields available, he may leave part of his land in fallow each year. In other cases he begins to use the manure of his own animals or acquired from neighbors. In certain cases within the Puebla area the farmer, besides adding organic matter, decreased the number of plants per hectare in an attempt to reach certain levels of production. The optimum stand per unit area tends to be lower at low levels of soil fertility.

These brief observations point up the following relationships:

1. The farmer, as head of a family, is responsible for the production of food for the maintenance of those who depend on him. The intensity of field work during certain periods requires the participation of all members of the family, thereby establishing certain production relationships at this level. If one considers the family as simply the economic abstraction "labor", one misses the essential nature of the farmer. This farmer is a man who has demonstrated his capacity to survive and to generate a whole technology of production. He is a man with enormous needs and with inherent aspirations consistently unsatisfied. To respect his dignity, his independence, his integrity and his moral values, is not only a requisite in these programs, but the very essence of his human rights. Once this principle is accepted, one should remove all types of paternalistic approaches which in the long run will make him dependent, indecisive and —this may be even more serious— pervert him and make him distrustful. From a philosophical point of view it is basic that the search for opportunities be on an equal basis for all. Through this process a clearer concept of responsibilities and rights is generated, and the conditions are established for initiating a democratic process in the lower strata of the society —where the social and economic problems normally are more serious and where the traditional farmer and his family are located— that may gradually extend upward to the strata where the structure of power and the major decisions generally originate.

Second Phase

As the population grows and crop yields decrease with the impoverishment of the soils, the needs of the farm families becomes increasingly more critical. Considering the Puebla area, an unsatisfied need at the family level, multiplied by the number of families, thus becomes a social necessity that can be solved only through the organized efforts and resources of producers, technicians, politicians and the state. The relevant points in this second phase are related to initiation of contacts between the farmers, the agricultural services and a well-trained technical team.

1. As the technical and social aspects of an agricultural problem become more difficult, in a country which is striving for development as is the case in Mexico, little by little the technical and scientific groups necessary to handle these problems, are formed. That is,

it generally requires a critical situation to provide the drive or stimulus for taking steps to solve it. Consequently a basic requirement must be policy directed toward the solution of these problems and the foresight to anticipate the consequences which may, in turn, present new problems.

2. Shortly after Mexico initiated its agrarian reform, fifty years ago, certain agricultural services were initiated. One of the first to be established was agricultural credit, even though agricultural research and extension were lacking. Agricultural credit was given but the farmer used his own technology, altered perhaps only by the use of better equipment and the use of fertilizers. This continues to be the case in much of the Central Plateau where a large population has lived for centuries. In the tropics the natural fertility permits slightly higher yields without the use of fertilizers. Unfortunately, the use of credit, with existing agricultural technology, yields very little increase in production. The result is that farmers frequently fall into debt.

From the point of view of the social process, the important fact is that those who operated the credit gave first attention to the interests of he bank. In general, they paid little attention to the farmer, who should be the one to decide how the credit would be used. Perhaps it was assumed that since the farmer owned the land and supplied the labor, he would learn automatically what was credit, what responsibilities he contracted through its use, what were the mechanisms of operation, what was the organization of the institution which offered the credit, how he should reimburse the credit, etc. Even now one may find within the area farmers who do not know the meaning of credit, nor how and when it should be repaid.

From this we may derive the principle that the initiation of agricultural services requires a simultaneous and coordinated effort. The introduction of new factors to the system of family production, disturbs an existing equilibrium. To avoid confusion the members of the family should be involved in every new action. Otherwise this disequilibrium will lead to a sequence of negative experiences, frustrating to the farmer and his family, and to those who foster and render the services. Modern techniques of communication may be valuable allies in bringing together all members of the families, motivating them and informing them about the new aspects which could affect family stability in the future. In other words, they can be incorporated into the change process but with a full understanding as to the objectives and probable consequences.

3. In addition to attaining good relations between the farmer and the agricultural services, the objective should be to prepare the farmer to assume his responsibilities as a producer and eventually as an agricultural entrepreneur. Although the service agencies —credit, crop insurance. distribution of inputs and others— attempt to take into account the technology obtained through agricultural research, these efforts may be futile if the farmer himself is not stimulated to change through an educational process. This education should be practical since the farmer will learn those things that he finds meaningful for fulfilling his needs and those of his family.

The farmer must begin to understand the process by which he moves from being a subsistence producer to one who produces in accordance with the demands of the larger society within which he lives.

At this point it is necessary to take into account the cultural context whithin which the farmer functions in order to establish a firm base for the changes that will occur. If one assumes that the farmer has been and is the product of his culture, he can also modify this culture. However, the changing situation should strengthen, and by no means weaken, the essential values of the society.

Third Phase

Since the farmer learned how to farm in his own physical, social and cultural environment, he must learn how to change it in the same context. In the Puebla Project, the technological transformation starts on the farmer's fields where the new experiences and results of the agronomic research have a clear meaning for him. Here he can evaluate the results on the basis of what he knows and understands. For the same reason the agronomic research in this environment also has meaning to the agricultural service institutions.

This experience has two main aspects: 1) it tends to improve the level of technology available, and 2) it strengthens the relationships between the producers and the agricultural services.

The work to improve the level of technology in itself brings the producer and the investigator in personal contact, helping to initiate a social process which in the Puebla Project has consisted of: a) The gathering of the information as to how and why the farmer cultivates maize the way he does, and b) the production of knowledge on optimum production practices —information that is then placed

in the context of the knowledge, interests and preferences of the farmer.

These two steps assume that it is important to fully understand the physical environment, but even more important to know the social environment in all of its facets. We must understand the farmer, his institutions, his organization and his behavior. Then we may propose and execute a plan of action that will lead to innovations relevant to the farmer in social and economic terms.

This means that if there are restrictions, for example, of capital, it would be incompatible for the research staff to produce in an initial phase, innovations requiring large capital investments. For this reason, the innovations generated by the research staff should be of a nature that demand a more intensive use of the land and family labor. Later on, as a consequence of a process of capitalization, other innovations requiring greater capital investments would have better possibilities of success.

Analyzed in this manner, the investigator becomes a research strategist. At the same time, the farmer becomes cognizant of the value of research and develops a high degree of confidence in the successive results. He shows this confidence by using the new technology. When the producer is the one who seeks out the researcher to obtain information, the sought-for change has been initiated and the cultural process of change becomes irreversible.

Then it becomes necessary to disseminate this knowledge to a large number of farmers —50,000 in the case of the Puebla Project. This activity is undertaken by other members of the technical team, persons who understand fully the process of production and the main factors involved. These men are the specialists in communications and extension, and they focus their work not on the farmer individually, but on the numerous communities in the area, in order to formulate a successful strategy for developing the human resources.

The second point mentioned above deals with strengthening the mechanisms of contact between the producers and those in charge of the agricultural services.

It is important to lead the farmer along the paths of change which the society in general demands. However, it is even more crucial to have the full involvement of those who make the key decisions in regard to the quantities and timeliness of credit, the availability of agricultural inputs, the specifications for crop insurance, the training in the use of these inputs, and other aspects. Once the results of research have been generated, those service institutions can immediately apply the results —results which are in themselves inputs of production and also constitute a form of insurance for the producer. The elements of this process also should be diffused in the urban sector and to other policy levels where important decisions affecting the rural sector, are frequently taken.

Seen in this light, it becomes clear why at the beginning of a program directed towards the transformation of a subsistence agriculture, it is basic to have the participation of the three human components indicated —producers, agricultural services and the technical research and extension staff. In its incipient stage, the problem seems to be of a technical agronomic nature, but in its total conception it is essentially a human process. Strictly speaking, the increase in yields —although important as part of the entire process— is only one part; the objective is the development of the human resources involved in such a way as to stimulate continued changes. These changes, in turn, will require new adjustments compatible with the combined changes that will occur in systems of work, objectives, organization and operation of the three human components. That is, the organization should be flexible enough to take into consideration the readjustments and adaptations which will arise in the human process just described.

ORGANIZATION AND COORDINATION

The first consideration is who will be organized and for what purposes. We have indicated the three basic human components in the Puebla Project. Let us examine briefly the function of each of these sectors in order to examine later their organization and coordination.

Institutional Sector

This sector carries out functions related to: 1) *national and state agricultural policy,* delineating the general framework and means of implementation; 2) *agricultural credit* from official as well as private sources, with the understanding that technical innovations require capital investment which the producers are not able to supply —private capital was essential in Puebla since the official institutions had limited funds available for this type of agriculture; 3) the *availability of the right agronomic inputs* at the farm level on time so

that knowledge can be converted into practice; 4) *crop insurance* which will reduce risks for the producer, and 5) markets for the products at *stable and attractive prices.*

The efficient functioning of these institutional factors depends on a small number of persons. These persons, besides complying with the norms of their institutions and the protection of their personal interests, should be alert to contribute efficiently in the process of production. This requires coordination with other institutions, all with the same objective: the transformation of agriculture to higher levels of productivity.

The Producers

In the case of the Puebla Project, the producers must make personal decisions about taking part, but they participate as a group.

In general, the organized participation of producers is obtained through methods that may be classified as: a) coersive, b) voluntary, or c) a subtle combination of both.

In Puebla it was considered essential that the farmers' decision to participate be voluntary. Although possibly more difficult, this allows the farmer a free expression of a personal decision to participate and to organize a group, not as an end in itself, but as a means of obtaining greater benefits from his efforts.

The choice of this procedure was based on the idea that the producer, by participating in the process, should not only enjoy the benefits of the Project, but also assume full responsibility for his own decisions and gradually contribute more and more to the success of the program.

The principles of organization should be conceived in terms of the following aspects:

1. The organization of the producers should be undertaken by members of the technical staff who are capable of understanding the social phenomena being induced.

2. The decision to organize, on the part of the producers, should be the result of a genuine interest in improving production as a means of raising their levels of living and responding to the demand for their products by other sectors of society.

3. The action to organize should be a decision to combine efforts on the basis of common interests; this implies that the individual is willing to learn to carry out group decisions.

4. The process of organization is initiated when the producers decide to associate in a common enterprise in which the individual exercises his rights in accord with the interests of the other members. The experiences derived from this process permit the group to function with its own norms, aspirations and goals. If, at first, they associate to obtain increases in production, their development will soon permit other functions such as group investments, livestock enterprises, industrialization and sale of their products, and the purchase and consumption of produce from other sectors of the economy.

This process also will permit the creation of a mechanism for improving their own physical, social and cultural environment, that is, their homes and communities. Although a community may receive benefits from government agencies, any substantial improvement should be generated by the community itself.

The Technical Staff

This small group has a vital responsibility in the strategy. It must generate an efficient technology that may be adopted by the farmers and supported by the service institutions.

This sector includes a small number of technicians and scientists. Reality dictates a small staff since the available technical and scientific personnel is limited and the cost of the program must be maintained at economic levels.

The *esprit de corps* of the technical staff should be based on the following aspects:

1. Team work in performing their roles — agronomic research, extension, intensive promotion at all levels, evaluation of the achievements of the program and efficient coordination of all factors involved in the strategy.

2. Interest and genuine dedication to the solution of problems arising during the process, without reservations in time or effort, until the postulated goals are reached.

3. Creative participation in group decisions and close inter-communication during the process of planning and carrying out the program.

4. A firm decision to be objective in their decisions and to sustain active relations with the members of the other sectors.

After we have examined the specific organization of each sector, there still remains the crucial step in the process: the efficient coordination of the three sectors.

Through coordination all of the participants eventually reach common decisions for solving problems and planning ways to more efficiently attain the goals of the Project.

Herein lies the reason for the key role of the farmer. The institutional sector is made up of some 15 persons. The technical staff

accounts for another 12. But the producer sector consists of 50,000 farmers, heads of families, who apply the labor and management skills involved in agricultural production. Clearly, the multiplication of the effects of the program will depend fundamentally on the farmers themselves.

The members of the institutional and the technical sectors must be better prepared, more audacious and have a greater vision of the social processes than their counterparts in more developed countries. This places a great responsibility on the academic institutions in charge of training this personnel.

CONSIDERATIONS IN ESTABLISHING THE PROGRAM

The key aspects to take into account in initiating this type of agricultural program are the following:

1. Feasibility —based on the ecological, economic and administrative resources available.

2. Social processes and effects —above and beyond the technological changes. A multidisciplinary vision is needed to operate this kind of program, using principally information from the biological and social sciences with special reference to human behavior and communication.

3. Development of the human resources, oriented towards the betterment of conditions that do not satisfy present human aspirations and are susceptible to change through the efforts of those involved.

4. Keep in mind that in the long run the goal is to establish a new mental structure, with norms directed towards the search for continued change, not a static situation with fixed norms and images whose change implies rupture and frustration.

5. Consider the organizational apparatus as an intermediate objective, a means for achieving more important goals. This apparatus should permit a harmonic expression of desires and interests both of the individual and the group.

As a consequence, one should also consider:

6. Changes occurring in one region should not be seen as isolated events with regard to what occurs in other niches of society. A substantial change in a given nucleus of subsistence agriculture will have repercussions in other sectors and will generate feedback causing still other changes.

7. These programs constitute a laboratory of human phenomena. For this reason, interest should be stimulated in other sectors of society responsible for teaching, research, extension, agricultural services, agricultural credit, agricultural policy, political orientation and government, so that these institutions may better fulfill their functions in social and economic development.

8. Although initiated with pragmatic objectives, this type of program provides an efficient medium for those involved to attain a complete vocational and professional fulfillment.

Finally, as a corollary to what has been said, we come to a point which, because of its importance, I have left to the end.

9. Because of the nature, aims and implications of these programs, they should be initiated, planned and carried out by the nationals of each country. These technicians and scientists will draw upon the experiences and knowledge of the entire world and will, if necessary, seek external aid. However, these national should be in a position to develop the programs which respond to the needs and aspirations of their countrymen to whom they must answer for their decisions and results.

a summary of what we have learned about increasing productivity among small land holders*

EDUARDO ALVAREZ LUNA **

We have heard three interesting case studies and reviewed in some detail the present status of efforts to reach the goals set forth in the Puebla Project.

To kick off the present discussion I will make a brief summary of what I feel we have learned about the essential factors of an effective strategy to increase yields and productivity among subsistence farmers.

Although this is a rather large task, given the complexity of the projects,the magnitude of the work, and the precision that has been attained in the coordination of activities, I believe that we all have a clearer idea now of what these projects are all about. Hopefully we can agree on several essential points resulting from these presentations. The following remarks are a summary of what I have learned.

I believe that an important point in these presentations has been one of *urgency,* and that there are several aspects to consider within this sense of urgency. First, it is urgent to diffuse quickly and efficiently the technology that scientific knowledge is providing in order to help subsistence farmers raise themselves out of their present conditions. For me it is urgent for humanitarian reasons, and possibly you will agree with me that everyone has the right to classify these priorities as he sees fit. For me, humanitarian considerations are of primary importance because all scientific efforts must focus on benefiting mankind.

The welfare of fellow human beings is the end we must keep in mind. The rural population, evolving at a subsistence level, has a high level of malnutrition as seen in the high incidence of infant mortality, premature death among adults, and irreversible damages in the development, physical as well as intellectual, of the people.

A nation requires the contribution of all its people, so that common efforts will be more efficient and it will be possible to obtain greater wellbeing in a shorter period of time. This is difficult to bring about if the burden is great and falls on only a limited sector of the population.

It is also urgent to diffuse technology and increase productivity for a reason which might be considered selfish. We cannot hope that any country, using only the limited resources of good land and the small force of highly efficient farmers will in the future be able to produce all of the food that an ever-increasing population will demand.

The Mexican Secretary of Agriculture stated that for this year, 1970, the probable corn harvest is 9 million tons, which is just barely enough, with a small margin of safety, to sup-

* Translated from the Spanish version by Miss Patricia Chain, Training and Communication Unit, CIAT.

** Agricultural Sciences of the Centro Internacional de Agricultura Tropical (CIAT) and Moderator of the Conferences.

ply the needs of this country. Demographic growth projections for Mexico indicate that 50 million people are living here now, and that there will possibly be a population of 110 million in 30 years. Since these future inhabitants are going to need twice as much corn, we will have to produce a minimum of 18 million tons, as well as providing for increases in demand as animal feed and for industrial production of food products. For this reason, it is estimated that at least 25 million tons of corn will be needed for the year 2000 These increased production needs, along with greater demand for other lines of agricultural production, clearly lead us to the conclusion that farmers in the commercial sector, high efficiency farmers, those who have quick, easy and opportune access to technological sources, to credit sources, to all the infrastructure which exists and which aids in the development of a country —these very important people from now on, no matter how much they increase their efficiency —are not going to be able to produce the food necessary for the future. For this selfish reason, to insure our own sustenance, we must do everything possible and even impossible to bring about rapid increases in the product .ity of subsistence farmers.

Another urgent reason for finding a solution to this problem is to stabilize the economy in order to prevent social conflict. The subsistence farmer can become a burden on the state and on the nation. But, a subsistence farmer who can overcome his limitations, who can feed himself better, who has a surplus, however small at the beginning, but of great importance later on, with which to begin his participation in the economic growth of the country, is perhaps one of the most important guarantees we can have of the investments made in projects of this nature. By increasing his productivity, we bring him into the economic growth of the country. He may create a level of demand for available articles and for new products, that we cannot even imagine at present. This in turn may cause a chain reaction in creating new jobs, in creating the wealth to give the country a greater economic stability, and in the end more social stability. By increasing productivity in the subsistence sector, these farmers can supply the necessities that a growing population demands, and give the country the opportunity for more active participation and greater profits within the international food market.

Recently, Señor Julián Rodríguez Adame, former Secretary of Agriculture for Mexico, on visiting Cali for the annual CIAT Board of Trustees meeting, told us of great future possibilities for Latin American participation in the international food market. However this will occur only if we can increase our efficiency, and if we can include farmers in the subsistence sector through raising their productivity. He told us that Japan, a highly developed industrial nation, depends heavily on foods produced in other regions of the world for its sustenance. The only line in which Japan is self-sufficient and enjoy surpluses is in rice production. Japan's imports currently total 14 billion dollars annually but, according to Mr. Rodríguez's figures, only 1.5 billion dollars are spent ni Latin America, the reason being that there is not sufficient production in our countries to export more. This is another favorable point in deciding to focus efforts and investments on programs to increase productivity in areas of favorable ecology with subsistence farmers.

Another general aspect of what we have learned these past few days is the feasibility of obtaining an increase in productivity within the subsistence sector. In fact, the philosophy and principles of this plan lead us to believe that it is feasible to apply them under different sets of conditions. This possibility is supported by the fact that, to a greater or lesser degree, we already have available an agricultural technology, or this technology can be produced rather rapidly in the place where it is to be used.

An increase in productivity is also feasible if we have a common effort to reach this goal. This may be a little subjective, but in all of the developing areas, the fact that there is an awareness of the problem means that the first step has been taken toward significant action. We have at our disposal resources, in quantity and quality, which can facilitate the initiation of these programs in all of our countries, independent of the greater or lesser degree of present development. If we analyze this thought in depth, we can conclude without pretention that there exist resources that can be channeled and coordinated into action and thereby lead to increased productivity.

Another aspect which makes the organization of this kind of project interesting and feasible is that experience now exists. We are building on a firm foundation. We have been witnesses to the progress made. We have learned of advances, results and experiences that can be useful in diffusing to other regions with similar problems the principles and basic philosophy which must guide a development project or plan such as the one we have observed this week.

From the presentations that we have heard we can synthesize a series of minimum requirements which have been proven necessary to increase agricultural productivity in areas of small land holdings with favorable ecology. It would appear that they can be of universal application in organizing and programming activities. From a personal point of view, and here I hope I'm not "carrying coals to Newcastle", I would simply like to try to impose a measure of order on the quantities of interesting information which have been presented to us. I believe that among the minimum requirements to have a basis for success we can point to the following:

We need to be able to count on a staff that is well-trained, skillful and motivated, to adopt and develop the technology necessary to bring about a change. Another minimal condition is awakening and attracting interest in the public sector to support development projects that benefit the subsistence farmer. This function might be considered only relatively important but, if we want to accelerate progress, then I believe that awakening the public interest to participation in these activities will be a determinig factor in the rate of progress and success.

Another minimal condition is a physical infrastructure which facilitates initiation and development of these programs. In this aspect, we must think about roads, the actual physical communications which permit and facilitate access by change agents, that is to say technicians, and which allow for movement of inputs and products.

We must also consider favorable ecological conditions for agricultural activity. Agricultural sciences are advancing, and each day we discover procedures, materials and equipment which permit us to work in harmony with nature under conditions that five years ago were considered completely adverse for agricultural activity and for man. Yet it would be inappropriate and even dangerous for the success of a program not to take this question of favorable ecological conditions into consideration

Also, there is a basic requirement, which is the existence of an agricultural services infrastructure, such as credit, input distribution, marketing, agricultural insurance, price guarantee, etc., in agreement with the established preferences of farmers. It is not indispensable that the infrastructure be of a sophisticated nature. The mere availability of these elements, even at low levels, is a point in their favor. It will be up to the change agent, or up to the coordination that can be achieved with these elements, to make the development scheme functional, and in turn generate more support as progress is attained.

I am reminded of a commentary heard by Mr. Rodríguez Adame, and made by an American economist when asked to say a few words on the economy of Mexico. The economist said, briefly and precisely, "In the Mexican economy, the distributive system does not operate from the middle class downwards" This is quite true, although not completely, since you will remember yesterday during the first part of our field trip we found two examples that show with interest and economic incentive, the distributive system can function

These examples were a soft drink distributing truck and a bread truck, both traveling on those extremely poor roads. I believe that it is a business for these people to sell refreshments, bread or food staples, then it could also become economically attractive to the fertilizer businessman, to the seed salesman, or to a promoter of other products and equipment. I believe that the day is not far away when besides seeing trucks with refreshments and bread, we will also see trucks carrying fertilizers —small moving stores that will bring to the producer the products, materials and agricultural inputs that his activities demand

It is also important that there exist a favorable relation bewteen the cost of production and the price the farmer eventually receives for his product in order to stimulate the incentive which is a prime ingredient of success.

Last but not least in this review of minimum conditions is the sense of urgency that must be felt by those who will focus their efforts on finding a solution to this type of problem. This factor is fundamental

After my presentation we will enter into a discussion of strategies. What is strategy? It deals with the means of overcoming or providing solutions to restrictions. For me, a guest at this meeting, like all of you, it has been truly satisfactory and educational to observe at first hand the experiences and progress being achieved in Puebla. The key to all this, within the strategy, has been the coordination of available resources· credit, research, infrastructure, marketing, etc. coordination that allows for a simultaneous attack on limitations, in order to reach the goal in mind. I believe that if I were asked to define the key to the success of this program, I would define it in just one word "coordination". There must always be motivation and a series of preliminary conditions, but coordination signifies efficiency in the manipulation of physical

resources, and just as important, an awareness of the human element. I believe that this is one of the great lessons that the Puebla Project offers to us.

For a successful strategy, it is important to select a region or ecological area which has problems of low productivity and high demographic pressure. This is important because the activities must be focused directly on helping the people who need it, and if these people are concentrated in a determined ecological or geographic area, the movement of change agents, inputs and products becomes much easier. This then becomes a part of the strategy because it allows for conditions which can reasonably lead to success.

The strategy must have flexibility in procedural operation to adopt to new conditions as they arise from the dynamics of the change situation I have the impression that Puebla Project as it now exists is not the Puebla Project of three years ago. The original concepts, planning and criteria have been modified as a consequence of the flexibility that has been of necessity applied to the strategy, in order to be able to adapt and take advantage of the changes generated by the dynamics of the general situation The Puebla Project can be a long-term enterprise and whoever evaluates it in the future will find, I believe, that this flexibility, this ability to change, this capacity to adapt, will be what allowed it to improve. I would like to think that in the year 1990 we would find that this self-same flexibility will have allowed the Puebla Project to attain its goals with greater efficiency, expressed in less time and cost, and in higher levels of production.

This strategy also demands a strict selection of the technical team. Those chosen must have great technical skill and just as important, motivation for what they are doing. Program evaluation procedures must also change, to allow study of the different stages of development. This evaluation, like stop-action photos, should let us see the progressive advances, retreats and detours which occur.

Another important point of strategy, in my opinion, is the orientation of the agronomic research, from obtaining knowledge of farmers' production problems to the use of the results by the farmers. That is to say, it is no longer research for the sake of research. It is research that keeps in mind the man who will use the results. Man, who is the basis of all these projects, has been in a sense forgotten in the process of agricultural research. We have always said that we are carrying out research and developing new varieties with better adaptation, with higher quality, with resistance to this and that, that we are finding agricultural procedures which allow us to efficiently use inputs, water, fertilizer, herbicides, insecticides, etc. But we have forgotten to make sure that the farmer, with his multiple and complex limitations, can efficiently use this technology. Mr. Magdub stated the problem succinctly when he said that bringing knowledge to the farmer, and forgetting about the problems he has when trying to use the information to increase production, is not fulfilling our mission as agronomists. A successful strategy, in a program that attempts to increase production, does not limit itself to informing —it must be oriented toward obtaining results that can be put to practical use. If this does not happen, all research efforts and everything invested will go down in history as just one more attempt without relevant results.

What I have done here has been to simply express my own ideas and concerns, derived from the interesting presentations that we have heard. Since this morning is devoted to discussion, I am sure that the presentations that follow will be able to complement this brief summary of what I think we have learned in these past few days.

possible roles of cimmyt in national programs to obtain rapid yield increases

R. J. LAIRD [1]

CIMMYT'S PRIMARY TASK is the promotion of basic food crop production, mainly corn and wheat, in ecologically favorable regions in developing countries throughout the world.

Experience gained in the Puebla Project during the past three years has demonstrated clearly that the Puebla strategy can stimulate rapid increases in corn yields. Simultaneously this strategy has created new attitudes among farmers and agricultural leaders, assuring that the transformation of agriculture in that area will continue.

We believe that this approach also can be employed to promote increased crop production in other areas with similar characteristics. Thus, CIMMYT has organized a program with the specific objective of assisting in the development of accelerated maize production programs in ecologically favorable regions in other countries which now have low yields.

With this objective in mind, our first responsibility is to provide information about the Puebla Project to leaders of agricultural development in Mexico and other countries. Hopefully, we can do this in such a manner that agricultural leaders can readily relate the Puebla experience to problems in their countries and evaluate its usefulness for them. This conference, for example, was organized precisely to inform and advise agricultural leaders of strategies for accelerating crop production and to stimulate interest in initiating activities similar to the Puebla Project.

Since the Project began in 1967, several thousand people have spent one or more days in the area, observing its operation. This effective way to learn about the Project will be used more extensively in the future. Reports, personal correspondence and the film you have seen, also are being used to interest agricultural leaders and others in the importance of the Puebla approach.

I wish to state clearly that CIMMYT is patterning its activities to accelerate maize production after the Puebla Project for two reasons: (1) this project is proving successful in rapidly increasing yields among small subsistence farmers, and (2) our staff has obtained a great deal of useful experience in this project. By no means are we suggesting that the Puebla approach is the only, or even the best, way to step-up agricultural production.

Should agricultural leaders in another part of Mexico or another country decide to initiate a Puebla-type program, CIMMYT is prepared to assist to the extent permitted by its staff resources and budget. At present we feel our resources can be used most effectively in providing assistance in: (1) identification of the project area, (2) selection of a team of agronomists to organize and operate the project, (3) training of the team of agronomists, (4) collaborating with the national program in

[1] Soil Scientist, Director of Production Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico.

the initial stages of operation, and (5) resolving budgetary problems.

I will discuss each of these areas briefly.

Identification of Project Areas

In selecting a project area, a basic consideration is that the ecological characteristics are favorable for high levels of maize production in most years. No rigid specifications in terms of climatic characteristics and soil properties can be given. However, the initial project in a country should be located in a region with sufficiently favorable ecological conditions to assure an ample increase in production. This is especially important because an extension of this approach to other parts of the country will depend greatly on the success of the initial project.

As a first step in selection, relevant information must be assembled to make a choice among alternative regions. This can be done by scientists in the country, preferably those who might continue to collaborate with the accelerated maize production program as it develops.

The following is a partial listing of the information that will be needed in evaluating the different regions:

1. Rainfall data. All recorded data from all meteorological stations in alternative regions. Monthly averages will be useful, but daily rainfall data for each month of the corn growing season and for all years will be more valuable.

2. Temperature readings. Maximum, minimum, and average temperatures. Monthly averages will be useful, but here again daily readings for the period of the growing season and for all years will be more valuable.

3. Evaporation pan losses. Monthly averages for all years at all stations.

4. Number of hailstorms and frosts for each month during the growing season.

5. Elevations above sea level at sufficient locations in the regions to permit a reasonable estimate of the cultivated area as a function of altitude.

6. Soil characteristics. The most useful information will be soil maps showing the distribution of soil types. However, if this is not available, any information on soils will be useful.

7. Geological, topographical and road maps of the regions.

8. Total cultivated area, number of farmers, area planted in maize, area of irrigated maize, average yields per hectare.

9. Information as in point 8 for several categories of farmers according to farm size. This information should be compiled by counties or other appropriate units.

10. Current level of corn production technology.

11. Marketing facilities for corn.

Once this information is available for alternative regions, CIMMYT can send one or more staff members with experience in the Puebla Project to join the country scientists in reviewing the information, studying the regions, and in recommending the most adequate area.

In CIMMYT's view, the study of alternative regions should be carried out by making a fairly detailed visit to the areas. At that time, the farmers' impressions can be obtained directly in the field, regarding the frequency of crop damage due to meteorological phenomena, importance of weeds and insects, soil characteristics such as color, texture, slope and depth, availability of agricultural inputs, interest on the part of local leaders, ease of communications, etc.

Selection of a Team of Agronomists

During the time that the project area is being identified, a search should be made for agronomists to form the project team. We believe that a team of five men should be selected initially for specific roles as: (1) coordinator, (2) maize breeder, (3) production research agronomist, and (4) two farm advisors.

The selection of the team of agronomists, and especially the coordinator, is perhaps the most crucial step. Candidates for training should be:

1. Highly motivated to assist farmers in improving their crop yields and social and economic conditions.

2. Willing to participate in field activities and to devote the time necessary for getting the job done.

3. Cooperative, with the understanding that team work among the agronomists is essential.

4. Equipped with good agronomic training, at least to the B. S. degree level.

5. Experienced in that aspect of maize production or the communication of information in which they are to be trained.

6. Physically fit.

In addition, the candidates should be natural leaders with an ability to communicate

easily with farmers, team members, leaders of agricultural institutions, and even the Minister of Agriculture.

Once a list of possible candidates has been prepared, CIMMYT can send a senior member of the Puebla Project staff to interview each of the candidates. Because of the importance of making an astute selection of candidates, we feel the effort and expense involved in getting an independent evaluation by a highly qualified person is justified. Hopefully, a person with several years experience in the Puebla Project will make an accurate appraisal of the possible candidates because he can better understand the kind of problems these men will encounter.

CIMMYT has fellowships available for the selected candidates, covering their travel and expenses during the training period in Mexico. A careful screening of candidates as described above provides a good measure of assurance that they will perform satisfactorily. However, after a few months in training if it should become clear that a candidate is not qualified for this type of production program, it will be in the best interest of all concerned to terminate his fellowship and name a replacement as soon as possible.

Training of the Team of Agronomists

Training of the team of agronomists is designed to: (1) provide the theoretical background and practical experience needed to operate an effective accelerated maize production program, and (2) encourage and train the candidates to advance professionally and assume an ever increasing role of leadership in the agricultural development of their country.

The training will be coordinated by the Graduate College at Chapingo in accordance with its academic regulations, and by the staff of the Puebla Project.

The College will be primarily responsible for study leading to the master of science degree and any additional theoretical training specifically required.

The Puebla Project staff will orient the trainees to the general philosophy, objectives, organization and operational strategy of the Project. Also, they will supervise the trainees within field activities of the Project for approximately one year. Trainees may enter the full program, which will require about two years, or they may receive only the one year's practical experience within the Puebla Project. The decision as to the exact training program for each trainee will be made as a function of their level of training and experience at time of selection.

If the trainees enter the full two year course in Mexico, some phases of the national programs, especially field research on production practices, should be initiated while the teams are being trained. There are several ways to do this. One possibility is to reorient the maize improvement and production research programs currently underway in the respective countries to accumulate the specific research information needed in the project areas. CIMMYT can assist the country research directors in planning the field studies that should be carried out in the Project areas during the interim period.

Trainees who come to Mexico for the two-year program will spend the first year in the Graduate College taking the course work required in the program. At the beginning of the second year the trainees will join the program of the appropriate staff member of the Puebla Project, and will be assigned the responsibility for a specific part of the overall field program. This will include the field research required for their thesis study. The Project staff members will assist the trainees in planning their field programs and in securing the necessary supplies, equipment transportation, and will supervise their activities during the year. After harvest, the trainees will analyze and interpret their data and prepare their theses. By the end of the two years the trainees should complete the requirements for an M. S degree in their respective disciplines and receive the practical experience deemed essential for initiating an accelerated maize production program in their country.

The course of study for the trainees at the Graduate College will be specifically tailored to the needs of the four categories of agronomists. It is expected that Coordinators will take an M. S. degree in Communications, Maize Breeders an M. S. in Genetics and Plant Breeding, Production Research Agronomists an M. S. in Soil Science, and Farm Advisors an M. S. in Communications.

The practical training in the Puebla Project also will differ for the four categories of trainees, and is designed to provide sound preparation in their discipline, along with capacity to carry out a coordinated program as a team.

Coordinators will spend most of their time working directly with the Coordinator of the Puebla Project. They will be assigned specific responsibilities for participating in field trials,

conducting interviews with farmers, supervising high yield plots, and holding meetings with farmers. They will work directly with the leaders of the various agricultural organizations and agencies in the Puebla area. Also, during the course of the year, they will be assigned for work with other staff members of the Puebla Project to become familiar with their techniques, ideas, etc.

The practical training of the maize breeders should prepare them to go into a new area, define the most promising genetic materials, and make use of the best maize breeding techniques to produce high yielding varieties with high quality protein. In addition, they will: (1) obtain a working knowledge of the available sources of germ plasm for producing improved varieties for different ecological conditions, (2) conduct field trials employing the most useful procedures available, and (3) learn the importance of maintaining all controllable productivity factors at optimal levels in these field trials.

The field program of the Production Research Agronomists should enable them to go into a new area, evaluate the ecological potential of the region for maize production, define the factors limiting maize yields, and carry out the field trials necessary for rapidly defining optimal levels of the agronomic inputs. Within this program, trainees: (1) evaluate the factors in the region which influence maize yields (nutrient levels, drought, excess moisture, weeds, insects, diseases, etc.), (2) assume direct responsibility for conducting field trials to measure crop response to nutrient levels, plant density, date of planting, etc., and (3) become proficient in methodological details such as treatment design, selection of field sites, experimental techniques, field observations, analysis of data, and estimation of recommendations.

Practical training of the Farm Advisers prepares them to: (1) assist farmers in achieving high yields in demonstration blocks on their own land, (2) collect information from farmers and related agencies for evaluation of the accelerated maize production program, (3) prepare information obtained in the program as a package of recommended practices, and (4) deliver this package of practices to farmers by the most efficient means of communication available under prevailing conditions.

To achieve this goal, trainees are given: (1) experience in the techniques of sampling and collecting information by means of interviews, (2) direct responsibility for conducting high yield plots with farmers, (3) information generated by the Maize Breeders and Production Research Agronomists to prepare a farmers' circular with the package of recommended practices, and (4) experience in conducting meetings with farmers and use of other media to communicate the package of recommendations.

Collaboration of CIMMYT in the Operation of National Programs

Our experience in the Puebla Project indicates that the teams of agronomists can benefit greatly from continuing technical assistance by highly trained specialists in the several disciplines. To insure this support each country should name a technical committee of at least three scientists —maize breeder, production research agronomist, communications specialist— to serve as technical advisers to the team of agronomists.

In addition, CIMMYT can assist by arranging for members of its staff to spend short periods of time participating directly in the national programs. The Puebla Project has proven to be an excellent model for organizing and operating an accelerated maize production program within its particular region. However, the situation in other countries will certainly vary and the national programs will have to be flexible enough to develop their strategies in terms of existing problems and opportunities. We believe that assistance by members of our experienced staff can be helpful to the national programs in making the necessary adjustments.

Budgetary Considerations

As mentioned earlier, CIMMYT, to the extent its resources permit, is prepared to assist in: (1) organizing national accelerated maize production programs, (2) training teams of agronomists for their operation, and (3) providing technical assistance to the programs during the initial years of operation. For a limited number of national programs, CIMMYT can arrange to purchase and insure a maximum of five pick-up trucks or similar vehicles to be used exclusively in the operation of the programs.

It is expected that the collaborating countries will assume the operating expenses of the national programs. These will include the salaries for the team of agronomists, salaries for approximately 20 field assistants (possibly local farmers trained by the agronomists); operation and maintenance of five vehicles, and equipment and supplies for conducting

field trials. Part-time secretarial help also should be provided. Equipment needs will include a large capacity scale (50 kg capacity), two smaller scales (2 kg capacity), drying oven, moisture cans, soil sampling tubes (4), work tables (3), hand sprayers (4) hand dusters (4), rain gauges (30), shovels, and a few other small items. Yearly supplies will include about 20 tons of fertilizers, herbicides and insecticides for treating 20 ha, fifty thousand paper bags, two thousand plastic bags, 500 wooden stakes, and several other inexpensive items. Estimated number of kilometers covered by each vehicle per year would be 45,000.

In closing, I would like to mention that the principal source of funds available to CIMMYT at this time for promoting accelerated maize production programs comes from Global Project 1 of the United Nations Development Program. The specific objective of this project is to promote the development and use of high lysine maize varieties. Consequently, CIMMYT's primary concern at this time is to promote accelerated maize production programs in those countries where the basic use of corn will be as a food for people.

open discussion of possible roles of development agencies in raising yields among small farmers

Presiding: KEITH W. FINLAY [1]

DR. STERLING WORTMAN who was to have appeared at this point on the program has asked me to convey to you his sincere regrets for not being able to be present. Unfortunately he was called back to New York urgently, and was therefore unable to fulfill this commitment which he had looked forward to for some considerable time.

Personally, I think it is unfortunate that Dr. Wortman was unable to be here today. He is an excellent speaker and has taken a great deal of interest in the Puebla Project. He also represents the Rockefeller Foundation, an agency which has done a great deal towards making the Puebla Project possible.

It is very difficult for a person such as myself, who represents a recipient agency, to say some of the things that I believe should be said at this point. The objective is to encourage representatives of funding agencies to discuss ways in which they can assist to stimulate the increase of production on small farms.

I will attempt to stimulate some discussion by presenting some ideas and drawing attention to certain points that have already been made during the conference or the visit to the Puebla Project.

Several speakers have stressed the urgency of the problem and I think that there is little need to stress this point further. There is a lot to be done with so many farmers at a low income level. It is evident that we have a real need to bring these people into the social and economic structure of the various countries in which they live. It is because of the concern for the social, scientific, educational, financial and other aspects of the problem, that various agencies have become interested. The aim of programs such as those that you have heard about during the past two days is to raise the level of production, and thus provide the small farmers with sufficient economic benefit to enable them to enter the social structure of their country, and also to provide them with the personal self-respect which accompanies such a change in social status.

I think it has become clear from our discussion, that the really important item is "people". We are not trying to raise production only, we are trying to change the way of life, to integrate people into a social structure within a country, and, of course, at a technical level we are concerned with the people that are going to help to do this.

The task of integrating large numbers of small land holders into the economic structure of a country is expensive work, both in terms of material inputs and human endeavour. For this reason, I think it is important to keep in perspective this type of aid program with regard to the total development of a country.

[1] Deputy Director General for Special Programs, CIMMYT, Mexico.

For example, if there are few educated agricultural scientists in the scientific services of the country, it is extremely important that these are not taken away and placed in a small concentrated program. This could well set back the technical progress of agriculture as a whole within a country, apart from removing the necessary scientific base from which the small project will need to operate. In instances of this type it is obvious that education itself becomes a major input and one which is becoming more critical as time goes by if countries are going to initiate and sustain agricultural progress.

The excellence of the people available to initiate and operate production improvement programs within small farmer communities is a basic factor which will contribute towards the possibility of success. If we look at any activity throughout the world which is making an impact, we will always find one or two individuals as the basic reason for the progress. It is an inescapable fact that the development of human resources, having the dedication, enthusiasm, training and imagination necessary to make an impact, is one of the critical factors in improving any form of agricultural production For this reason, I suggest that training at all levels should receive an increasing share of attention from funding agencies.

During the last two days we have heard a lot about credit. We have had examples quoted within Mexico itself of small farmers receiving credit to a limited extent. I must admit I had not appreciated that the farmer may have to pay interest ranging from 8 to over 50%, depending on where he obtains the credit. There seems little doubt that credit for the farmer to enable him to purchase the necessary inputs to increase the efficiency of his farming operation is another of the fundamental factors which needs further development.

It is also of some interest I think, to hear that an extremely high proportion of small farmers repay the credit provided. The new farming systems developed with the improved technological developments, enables them to repay their loans and still be much better off than they were on their old farming system.

All the projects that we have heard about contain a component of mutual assistance between farmers within the regions being studied. Techniques designed to form cooperatives, or mutual assistance groups within the farmer communities are an important component to encourage the rapid spread and efficient self-education necessary for continued progress. The development of leaders among the farmers, which is stimulated by this technique, must surely be an important contribution.

I think that Dr. Jiménez made a very important point with regard to the dynamics of a program such as the Puebla Project, and one which leads us to consider what it is we are trying to do in a project of this type. We are trying to change the system; to improve it. The word 'change' itself is a dynamic one and it implies that the organizations and farmer groups involved in this system of change must be prepared to adapt to the changes that they are producing. I think that this is a point which is too often overlooked. As soon as we achieve a satisfactory level of progress we tend to try and p rpetuate that state, and in so doing, remove one of the most essential features of the system —dynamic change.

This point raises, for serious consideration by funding agencies, the question of flexibility of funds provided to action agencies for this type of program. There has been a growing appreciation of the fact that a certain degree of flexibility in the use of funds is essential if action agencies are to operate efficiently. I would like to suggest however, that funding agencies should look still further at this point. They should consider ways in which the inbuilt protection for proper use of funds can be continued, but at the same time, sufficient flexibility can be provided for the action organization to adapt and move with the changes it helps to create.

It is pleasing to see such a large number of funding agencies represented at this conference. It has also been extremely gratifying to find the number of organizations who are anxious to find ways to further improve the overall production and social status of small farmers.

There are many of you here today who represent organizations which have had a great deal of experience in small farmer programs in other parts of the world, and I would like to now ask you a question. How can funding agencies, and others that are concerned in this area of aid, stimulate the type of activities that we have been discussing for the last couple of days? Can any of you provide information from your own experience, or that of your agency, which will stimulate further

discussion and ideas while we are here together? There is no attempt to commit anybody in any way. However, this is an ideal opportunity to exchange experiences and ideas, and to open up discussions, so that we may all move ahead much more confidently and quickly with our attempts to solve this critical area of human need.

discussion

HUBERMAN. I want to point out what we have to learn —what is the nature of the elephant has four legs, and here in the Puebla Area we might consider one leg to be the group; another leg is the technical team headed by Dr. Jiménez and his colleagues. The third leg would be the institutions of credit, and other government and private agencies. And the fourth leg is the technical backstopping provided by CIMMYT— those doing the experimental work and the research, not just for immediate answers but also for new information on all phases of production practices, insect and weed control, new breeding methods, and the technical team which brings these research answers to the farmers and puts all of these things together. My question is, Dr. Jiménez, is this a correct understanding of the message presented during yesterday and today?

JIMENEZ. Yes, that is the elephant that we have to construct.

PIERCE. The BID is concerned with promoting financing for this kind of project. There is also an interest in education, and we have already started financing technical education. I think that we could help develop the capabilities of people to carry out projects, for example, credit. In developing the credit system, it would be necessary to prepare people. We would be willing to participate in the process. However, we would probably want to think of thi son a national basis. Our questions would be along the following lines. How can the work of CIMMYT benefit? How can the national institutions benefit? What does it take?? Could there be a Puebla Project on a national basis? What would be the linkages? Those are my questions.

FINLAY. Just a comment on this. On a meeting with the IDB, about 12 months ago, I was slightly embarrassed by the directness of their questions. They said "We've heard a lot about wheat and rice in the Middle East and Asia and other various places. What are you doing in Latin America? What are you doing with this crop and that crop, and so on? We are very pleased that these questions are being asked. They have stimulated a tremendous amount of thinking. Are there other questions or comments?

WILLIAMS. My general question relates to responsibilities. Who is going to participate in which way so as to take a primary role in developing programs like this. The Puebla Project generates something more than a system for distributing fertilizer. As one goes beyond this, it opens up an opportunity for introducing different types of inputs and services. For example, I remember a discussion related to the ability to meet the demand for fertilizer. At some point it becomes possible to capitalize and expand the organization. It then becomes of greater interest to those who are concerned with funding projects. I would suggest for your consideration, that the Puebla Project gives to its planners an opportunity that simply is not normal. That is, they must be aware of when their participation exists and what are the different types of opportunities. The investment sector could be a marketing organization, an expanded network for distribution of agricultural inputs. When private investment capital is drawn in and it is profitable, it begins to expand under its own momentum to do exactly what you are trying to do with funds which are not reproducible. Capital can be created within this project.

EVANS. I would like to suggest some things that international funding agencies can do, and seem to be key points in the Puebla Project. In his introductory statements yesterday, Dr. Laird gave a very interesting review of what would be the ways for helping. The green revolution has made a substantial contribution to the development of agriculture. Some years ago many people saw the situation as rather hopeless; now they have hopes that the problems can be solved.

This is one of the things that has been achieved by the work of CIMMYT and IRRI, and which we hope will result from the work of IITA and CIAT. If we are going to proceed with improved technology, we in the World Bank will have to make available additional funds to carry out on the work of these international institutes in order to develop and test the new technology as CIMMYT and IRRI have done.

If we look at the world picture, we find many parts of the world and thousands of millions of farmers who cannot reap benefits from the new technology because they do not have any prospect of obtaining the full package of inputs. Also there are crops produced by many millions of farmers in the world on which very little research has been done. Legumes need more attention.

There has been discussion between international agencies such as UNDP, FAO, the World Bank, and the regional banks that suggest to us in the World Bank that it is possible to help support research. I think we should help to develop improved technology and that our priorities should be:

First of all the production of improved technology, by helping to improve and expand research.

The second is what we used to call *extension.* It seems to me that 15 or 20 years ago we were all talking about extension as a kind of panacea. Everybody wanted to raise the small farmer's productivity through extension services. The results were disappointing in some cases because it was difficult to obtain the desired reaction from the farmer and to make him feel the needed incentive. The farmer needs to see the possibilities for significant increases in production, such as are now possible in some cereal crops.

When we have the improved technology, then we need the services to extend it to the farmer, and here, of course, is where personnel becomes an important issue. We have to provide for training people. This is one thing for which the international funding agencies can provide much of the financing which is needed.

Another important aspect is credit. There have been some interesting references to credit in the meetings of yesterday and today. Most banks are interested in providing funds for farm credit. However, there need to be worthwhile farm enterprises in which farmers can engage. The kind of channels for credit vary from country to country, and sometimes one has to suggest improvements and make rather unpopular propositions about interest rates. We heard yesterday figures of 1% and 1½% and more per month that farmers have to pay. Very seldom, I think, can rates as high as 2 or 3% a month be justified. On the other hand, I do not think it pays for a country to suggest that it is able to provide credit at rates of 2% or 4% a year. As far as I can see one has to be able to propose rates which are not too far from those charged by commercial banks before you can get support from lending agencies.

I think that the Puebla Project is an interesting example of what can be done where you have the possibility of combining improved technology, arising from the work of CIMMYT, and the excellent extension arrangements that we have seen at Puebla this morning, and where credit and assistance are available.

I would like, before concluding, to say something about the involvement or private sources of finance to which Dr. Williams referred. This is of high importance because the public sector and public agencies by themselves are not going to be able to provide what is wanted, nor should they be expected to do so. I think we have to find ways to show the private commercial banks it may pay to invest their money in agriculture, even when the farm holdings are small. It may be possible to do this by arranging discountings by private banks or through some mechanism that may be operated through a central bank. This kind of arrangement is known in Mexico and is proving possible in other countries.

The final point I would like to take up is your point about flexibility. I think that most agencies appreciate it and are working in one way or another to achieve it. We are trying to be flexible in terms of the kinds of projects for which we may provide funding and credit.

FINLAY. Dr. Jiménez made a point during his presentation about the impact of credit into the Puebla Project and the growing con-

fidence of the banks. Personally I have been surprised at the high repayment rate that has been coming from the Puebla Project.

This question of capital and credit, as some one mentioned also is important for extending the Puebla Project. In Mexico there are four states that have indicated interest in planning work similar to the Puebla Project set up — in fact, one is in the planning stage. The money for this will come almost exclusively from local sources.

CIMMYT has been asked wether it would initiate and run such a project in another state. We said no, we would not. If the Puebla Project is going to be a success as an experiment, the next move must be the taking up, initiation and running of this kind of program in other areas by local governments and people.

We are also concerned with what I call the multiplier effect. This is just one valley in Mexico. There are many other valleys in Mexico, with lots of people, and there has to be a multiplier effect. We feel that the one part of the multiplier effect that we, as an international institution, should support, is the educational aspect. We can help to educate teams that can, in turn, go out and initiate others. For this phase we have as yet little or no experience; any information, knowledge, experiences, or comments should be thrown into the discussion here.

DE TUDDO. The FAO is not a funding agency —we are a technical agency— but we are involved in rural development around the world, and I would like to refer to some problems related to the possibility of improving the conditions of small holders in environments more critical than the Puebla Project area.

What can we do to help others enter into the commercial stream under even more critical conditions, such as Oaxaca? Oaxaca is one of the poorest states in Mexico, in which the small holders are living in very poor areas, isolated, with no extension, no credit, no research, soil fertility destroyed. Ancestral system of behavior. Illiteracy runs very high, forestry is destroyed year by year.

We must find the way to bring about some sort of change. We must take the responsibility, as technical agencies or scientific institutions. We are sure something can be done. It is very easy to say that nothing can be done. But we must together try to find for these people something of the beautiful achievements we have seen in other areas.

FINLAY. I would like to find throughout Mr. Mackenzie, who represents one of the oldest agencies in international development, to raise any point that might be relevant, and then I am going to throw a question of the Canadians, who are one of the youngest group in this area, for any kind of comments they might wish to make, just to try to obtain a range of comments from various regions.

MACKENZIE. I find the Puebla Project interesting and in fact a great break-through in doing something for the small farmer. I have experience in quite a number of countries now, and meeting the farmers this morning and after hearing the details of the scheme, it has been most cheering to me that it has made an impact that is not often seen in other parts of the world. It is something that CIMMYT and the Mexican Government can be very proud of.

But it brought horrible spectres in my mind. One of them is the dominance of just one crop —maize. Now, some of the remarks indicate that certain farmers were well aware that they should now diversify their crops. I think this is the greatest risk for a loss because if the Puebla Project reaches 80 or 85 percent of farmers, where are the farmers going to sell all of the corn? If they can't sell, what will be the price? Here I think one most look to the future when you see after two or three years of work that you are going to be successful. Then CIMMYT must say to itself "Yes, we are pushing on with the scheme, but we must help farmers to diversify their farming, so that they can avoid the dependence on just one crop".

In making this comments I have in mind several examples of market price dropping with sharp increases in production.

This is not a criticism of CIMMYT because this is one of the few cases in which I have seen a research organization actively engaged in development work in the field. I would appeal to more research officers to leave their offices, and carry their research to the field.

PETERS. Canada is fairly new in this business of institutional support. In Canada we have the Canadian International Development Agency (CIDA), which, of course, is the new name for the Canadian aid program. We also have the new international research center which is just coming into being. At present we are going through a survey to assess what type of support Canada should give to the various types of institutions. It appears at the present time that CIDA will be giving core support to the International Institute of Tropical Agriculture. We have committed close to 4 million

dollars over the next four years —it is a five-year plan, and it has already been underway for one year We are very proud of that association and hopefully we will move into other institutional support.

As to the new research center, because it is a research center, it is logical to expect it to support programs and projects, but that will be entirely up to David Hopper, the new president, and the international board of trustees that controls the operations of this autonomous center. I want to point out that it is not a research arm of CIDA.

This is my second visit to the Puebla Project, and I have learned as much this time as I did last fall during my first visit. Thank you very much.

STEPPLER. First of all I would like to amplify what Stuart has said about us being new. We only raised our flag three years ago. Second, I wonder what kind of an elephants because I thought we were going to be treated to the full analogy. And I wonder what the trunk is, whether this is the catalyst. Maybe this is where the funding agencies may come in —as a catalyst.

I do wonder if the people who were here at the beginning of the week, should not be sitting here with us at the end of the week. It seems to me that we have at least two things. One is the question of whether or not we should have more Puebla experiments, which might well be conducted by CIMMYT and other international institutes such as IRRI, IITA or CIAT, and might include as my friend suggested at least one kind of experiment where you are dealing with a multi crop system, as opposed to a monocrop. The other question is support for nations to carry out regional programs of the Puebla type, designed to raise the standard of living or the purchasing capacity, or whatever your objective is within the region. In extending the Puebla approach I think we are talking about a proposition in which the government and the people of a particular national area are concerned and the international institute is merely a back up; it is merely providing some of the research information. The national institutes within that country must become very deeply involved. And here again the funding agency, such as our own or some of the others, might then wind up as the trunk, as the catalyst.

MOSHER. What is there in the Puebla Project that might be useful to other Projects in Asia? It seems to me that the really unique thing here is the research input.

Another real contribution is the methodology for rainfed areas. In the research aspects you have here the production strategy, the weather corrections, the type of experiments you have been carrying out. This may be useful for many people in the world, trying now to establish and adapt research programs for rainfed areas like Puebla.

DELGADO CASTILLO. I imagine that what the Puebla Project has done so far is just a part of the whole Certainly, it has been successful in production, in the technical aspect. But something should be added here. improvement of the community. I would suggest to add community development. I know that there are people with good experience to support this kind of project, where the goal is to help people move ahead not only for a few days, but for a larger period of time.

FINLAY. The session will be over soon, and I am going to return the chair to Dr. Alvarez. There may not be an opportunity at the end of the session, so I would like to take this opportunity on behalf of all the people here and particularly in behalf of CIMMYT, the Puebla Project team and the people associated with it, to thank Dr. Alvarez for his excellent chairmanship during this conference.

participants

Herbert R. Albrecht, Director, International Institute for Tropical Agriculture, P. M. B. 5320, Ibadan, Nigeria.

Per-Pinstrup Andersen, Agricultural Economist, International Center for Tropical Agriculture, Cali, Colombia.

Randolph Barker, Agricultural Economist, International Rice Research Institute, P. O. Box 583, Manila, Philippines.

Francis Byrnes, Deputy Director for Training and Communication, International Center for Tropical Agriculture, Cali, Colombia.

Guy Camus, Director General, Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France.

Enrique Delgado Castillo, Agricultural Economist, FAO, Inst. Tecnológico de Monterrey, Nuevo León, México.

Paul C. Duffield, New Mexico State University, Box 3567, Las Cruces, New Mexico, U.S.A.

L. J. C. Evans, Director, Agricultural Project, World Bank, Washington, D. C.

Vernon Ferwerda, R. P. I., New York, U.S.A.

Darrell Fienup, Program Advisor, Ford Foundation, Ayacucho 2151, Buenos Aires, Argentina.

William Gamble, Representative, The Ford Foundation, Reforma 243, México, D. F.

U. J. Grant, Director, International Center for Tropical Agriculture, Cali, Colombia.

Clifford Haslam, Vice-President, ADELA Investment Company, Reforma 364, México, D. F.

H. Stuart Hawkins, School of Agriculture, University of Melbourne, Parkville, Victoria, Australia.

Reed Hertford, Program Advisor, Ford Foundation, Apdo. Aéreo 52986, Bogotá, Colombia.

M. A. Huberman, United Nations Development Program, New York, N. Y.

Carlos Krug, Member, CIMMYT Board of Directors, Brazil.

Malcolm MacDonald, Planning Office, IICA, P. O. 4359, San José, Costa Rica.

A. F. Mackenzie, Deputy Agricultural Advisor, Ministry of Overseas Development, London, England.

Arthur T. Mosher, President, Agricultural Development Council, 630 Fifth Ave., New York, N. Y.

C. L. Pan, Representative to the UNDP/CIMMYT High Lysine Project, FAO, Rio de Janeiro, Brazil.

Stuart S. Peters, Canadian International Development Agency, Ottawa, Ontario, Canada.

Clarence M. Pierce, Inter-American Development Bank, 808 17th Street, Washington, D. C.

B. L. Renfro, Inter-Asian Corn Program, The Rockefeller Foundation, New Delhi, India.

Vernon E. Ross, Rice Production Specialist, The International Rice Research Institute, Box 583, Manila, Philippines.

Sidney Schmuckler, Inter-American Development Bank, 808 17th Street, Washington, D. C.

Howard A. Steppler, Agricultural Advisor, Canadian International Development Agency, Ottawa, Canada.

Angelo A. de Tuddo, Representative in Mexico, FAO, Hamburgo 63-4, México 6, D. F.

Simon Williams, Gerente General, Coordinación Agrícola, A. C., Guadalajara, Jalisco, México.

NOTE: This list does not include those participants who presented formal papers, nor members of CIMMYT staff.

VISIT TO THE PUEBLA PROJECT

Both conference programs included visits with farmers and a review of experiments in the Puebla area. The participants saw the production research program and the corn breeding work at Palmillas and San Mateo. They also took part in meetings with farmers at San Luis Coyotzingo. These visits were organized by the Coordinator of the Project, Ing. Mauro Gómez. The experiments on agronomic production factors were explained by Ings. Alvaro Ruiz Barbosa, Nestor Estrella Chulín and Raul Castillo Losoya of the soils program. The corn breeding work was explained by Ing. Tarcicio Cervantes and Ing. Hugo Mejía. The visits with farmers were organized by Ings. Felipe Rodríguez Cano, Gildardo Espinoza S., José de Jesús Guerra M., Francisco Escobedo and Aristeo Alvarez of the farm advisory team of the Puebla Project.