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INTERNATIONAL MAIZE AND WHEAT
IMPROVEMENT CENTER

Sustainable Improvement of Agricultural Production Systems in the Mixteca Region of Mexico

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Abstract: With support from the Conrad N. Hilton and Ford Foundations and in collaboration with three Mexican non-governmental organizations, the CIMMYT Natural Resources Group (NRG) worked with small-scale farmers in the impoverished, semi-arid region of southeast Mexico known as the Mixteca during 1998-2001 to increase food production and improve the quality of rainfed, maize-based agro-ecosystems. Participants worked in four communities to help farmers identify and test a set of 19 technologies. The most promising were green legume cover crops and grain legumes such as lablab and pigeon pea, oyster mushroom production by a women's group in one village, drip irrigation for home gardens, greenhouse cropping, selection among local maize varieties, and triticale production. Several of these have been adopted in the communities. The project also bolstered farmers' self-esteem, community spirit, and communication with peers, and enhanced local leadership, organizational, analytical, and experimentation capabilities.

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Contents

Tables

Figures

Executive Summary

The Mixteca region is located at the convergence of the states of Puebla, Guerrero, and Oaxaca in southern Mexico. The failure of subsistence agriculture, lack of alternative employment, and general marginalization of the population in the region have resulted in high rates of rural flight in recent decades — fully half of the population has left to seek opportunities in Mexico's larger cities or the USA. The region's economy depends on agriculture and livestock production, especially goat herding; earnings obtained through street vending, construction work, handicrafts, and gathering of wild fruits and other plant products; and (last but not least) cash contributions from relatives working in cities. Farming is risky and unable alone to provide household food security. Comprising mainly rainfed maize and bean production, with some cultivation of garden vegetables and wheat, agriculture suffers from insufficient and unreliable rainfall, poor soils, low or null use of inputs, and a lack of technical or financial support.

With funding from the Conrad N. Hilton and Ford Foundations, the CIMMYT Natural Resources Group (NRG) began work in 1998 to improve local livelihoods through farmer testing and promotion of agricultural technologies that could increase food production and contribute to the quality of agro-ecosystems. The project also sought to bolster farmers' self-esteem, community spirit, and communication with peers. To accomplish this, participants worked with four communities and three other organizationv¡in planning, to identify and test a set of 19 improved options, and in promoting those which proved most relevant and productive. Some 50 peasant farmers (20 of whom were women) helped design and conduct the experiments, with technical and other support from project agronomists. The participation of women farmers was particularly significant, given their central role as food providers in households where men of economically productive age are working off-farm.

Given the region's lack of water, farmers are strongly concerned with finding, testing, and implementing ways to capture moisture and utilize it more effectively. Participants have encouraged and contributed to local discussions about natural resource management and its relevance as a platform for long-term development. But subsistence farmers are not intrinsically interested in ecological conservation or restoration *per se*; in addition to conserving precious soil and water resources, any farming systems or practices proposed must also increase food production and/or incomes to have a chance of gaining acceptance. Finally, participants have sought ways to extend the efficiency and lifespan of existing soil and water conservation works.

The approach used heavily emphasized local management, evaluation, and adaptation of the selection and experimentation processes, encouraging farmers themselves to take charge as the main actors in local agricultural development. Researchers have provided key input, where relevant.

As a result of the above, the farmer-experimenters who have taken part have a clear awareness of the problems they face (with the exception of the full environmental impacts of goat herding) and a menu of technical options for addressing these problems — several of which have been tested extensively and are already being adopted in the communities. In addition, there is now a critical mass of progressive local farmers with enhanced leadership, organizational, analytical, experimentation, and communication capabilities. They have understood the value of testing potentially useful practices scientifically, have seen the relevance of sharing results with peers, and are now serving as enthusiastic promoters of specific technologies and, in general, agents of agricultural and community development.

The Mixteca Region

General characteristics

The Mixteca is located in southern Mexico on the borders of the states of Oaxaca, Puebla and Guerrero (Fig. 1). The prevailing climates are semitropical (Acw), temperate semi humid (C(w)), temperate semiarid (Bs1k), semiarid (Bsh), semiarid semitropical (Bs1h), tropical semihumid (Aw) (INEGI 1996; 1997). The terrain is mountainous. Altitude varies between 1,000 and 3,000 m above sea level (masl). Above 1,900 masl, frosts occur from mid-October to March. Vegetation is low deciduous forest with a predominance of bushes (thorny legume trees), cactus and grasses, maguey; low thorny forest, thorny shrubs, oak woods, and pastureland (INEGI 1996; 1997; SAGAR 1999).

Project activities were centered in the Oaxacan Mixteca, a region comprising 1,958,382 ha, 8 districts, 165 municipalities, and 1,419 villages. Of its nearly 500,000 inhabitants, 68% live in rural areas and 35% belong to one of several indigenous groups, including the Mixtecas (predominant), the Triqui, the Chochomixtecos, the Amuzgos, and the Tacuates (SAGAR 1999). The languages and cultures of these groups are slowly disappearing, as the poor flee the countryside and basic education erases native culture and tongues.

The prevailing climate is semitropical (Acw), semitropical temperate (C(w)) and temperate semiarid (Bs1k) . Annual rainfall ranges from 300 to 750 mm, with a very erratic distribution between June and October (Fig. 2). Rainfall in the project area was around 450 mm in 1999, whereas in 2000 it ranged from 250 to 400 mm, depending on the village, with a dry spell of from 21 to 40 days during July-August. The terrain is mountainous, and farming takes place on small spaces at the edges of gullies or rivers, on hillsides, hilltops or in depressions.

Mixteca soils generally lack organic matter and are deficient in nitrogen, zinc, sodium, phosphorus, iron, carbon, and potassium. They range in pH from 6.8 to 8.7, and are of medium texture, except in certain areas of clay soil. In the Lunatitlán-Nochixtlán-Zapoquila area, most fields have slopes of 9 to 20% and 10 to 25 cm of topsoil. These soils, known as white and *shallow soils,* are the poorest because they are shallow and prone to erosion. Local inhabitants term the land alongside streams “porous land”. Such soils are deep (40 cm or more) with medium texture and good fertility, as a result of deposits from rainy-season watercourses. They are also more productive than the norm because farmers who work them normally have access to enough water for at least one irrigation, in case of an extended dry spell. Soils in intermediate areas between the slopes and riverain lands are diverse and of fair quality, being composed of medium-size soil components washed down from higher land.

The local economy is based on agriculture (maize, beans, and wheat) and livestock (goats, cows, and sheep) production, on money sent back by relatives working outside the region, and on earnings from street vending, construction, handicrafts, gathering local fruits and plants, and hired fieldwork. Handicrafts include weaving hats (sombreros) and piecework to produce soccer balls. And production of the basic staple crops mentioned above fails to satisfy local demand. In addition to the crops listed in Table 1, farmers grow birdseed, faba bean, groundnut, watermelon, capsicum peppers, squash, amaranth (increasingly popular), peach, and avocado. Fruits that grow wild in the region and are collected include *guaje,* red prickly pear, *xoconoshtle, jiotilla* and *tempesquistle*.

Table 1. Basic statistics on rainfed agricultural area and livestock production in the Mixteca.

	Area sown (ha)
Total rainfed cropland	126,781
Monoculture maize	31,550
Maize + climbing bean intercrop	9,993
Monoculture bean	13,286
Bean + maize intercrop	4,282
Wheat	14,560
Area used for raising livestock	690,129
	# of heads raised
Goats	428,473
Sheep	141,634
Cows/cattle (milk, meat)	107,381
Draught cattle/oxen	107,751

Source: SAGAR 1999.

The low productivity of agriculture in the region is exacerbated by and has intensified the migration of youths over 14 years old to seek work in larger Mexican cities or in the USA (often as undocumented workers). Those who remain behind are either the elderly, who often have little interest in or strength for farming, or the very young who look for the first opportunity to leave.

Traditional, maize-based farming systems

Agriculture is a risky enterprise in the Mixteca. The region's chiefly maize-based systems feature extensive use of hand labor, little use of external inputs, no mechanization (typically draft animal power), no access to credit or technical assistance, primitive infrastructure (if any at all) for water harvesting or utilization, and little irrigation. The most technologically advanced zones are the alluvial valleys of Tamazulapan, Coixtlahuaca, and Nochixtlan (SAGAR 1999).

Some form of maize-bean-squash intercrop accounts for about 15,000 ha in the region. Yields vary greatly as a result of the difficult environment; in the case of maize, from as low as 0.45 t/ha in the predominant, shallow soils to 2.5 t/ha in the intermediate, clay, or porous soils in a good rainy period. These yield levels, taken from the relatively small areas farmers typically sow (from 0.125 to 1.0 ha), fall far short of household food requirements.

Maize cropping activities are the following, in chronological order (Fig. 3):

1. Plowing.
2. Cross plowing to eliminate weeds.
3. Furrowing, hand sowing, and foot tamping carried out by women and children.
4. Cultivation and manual weeding 25-30 days after sowing.
5. Hilling up and manual weeding about 50 days after sowing.
6. Detassling.
7. Harvesting ears.
8. Hand shelling as required.
9. Cutting and storing stover.

Before plowing or cultivation, organic fertilizers (goat, cattle, or horse manure) may be applied. Applications comprise approximately 3 kg per straight meter, each line being separated by approximately 85 cm. It is also applied in patches on the most deteriorated areas.

Maize farming has developed in response to environmental and management conditions. Varied rainfall patterns in the area have influenced phenological cycles and conferred a high degree of drought tolerance. Seed selection of local varieties interacts with management practices: farmers define suitable sowing dates and management practices for different varieties when sown at different sites. Sowing dates vary among the three communities even though they are separated only by short distances. However, flowering and grain filling coincide with the wettest time (end of August to the beginning of October), which in turn depends on the hurricane season. Given the semiarid conditions, plowing and cultivation are done transversely to the slope to capture and retain moisture.

Constraints to agriculture in the Mixteca

The main production constraints are drought, erosion, and poor soils (Cruz 1988), together with overgrazing (Cruz and Bravo 1988) and frosts (SAGAR 1999).

The shortage of moisture from insufficient rainfall is exacerbated by soils' poor capacity to capture and retain water. Erosion has worsened, as farmers abandon former practices of soil conservation, such as terraces and soil and stone wall barriers. Excess tilling is common; and rotations have disappeared. Hillside fields where slopes exceed 12% can suffer losses of more than 70 t/ha each year; far beyond the permissible levels of 6.7 t/ha for hillsides (Bravo 1990). Overgrazing has compacted soils and deprived them of crop residues. Finally, frosts can damage crops in highland zone during October-February.

Farmers lack access to credit or technical support, such as management packages for low-yield environments. On occasions when farmers wish to market excess production, they must sell it to intermediaries at below-market prices. Adding to Mixteca inhabitants' woes are the lack of a viable job market, uncertain land tenure, low educational levels, the disinterest of seed companies or other distributors of agricultural inputs, and the absence of effective research or extension activities for the region.

The Mixteca Project: Participants and Activities

The project "Sustainable Improvement of Agricultural Production Systems in the Mixteca" (hereafter referred to as "the Mixteca Project"), undertaken by the International Maize and Wheat Improvement Center (known by its Spanish abbreviation, *CIMMYT*), began as a complement to the project "Water Forever" conducted by the Mexican non-government organization *Alternativas y Procesos de Participación Social, A.C.* (known as *Alternativas*), an effort aimed at promoting and focusing local action for locating or harvesting water for agriculture. Both projects were funded by the Conrad N. Hilton and Ford Foundations and were intended to improve the livelihoods of Mixteca inhabitants.

CIMMYT is a non-profit research and training organization headquartered in Mexico that works throughout the developing world to improve the wellbeing of farmers and consumers who depend on maize and wheat for food and incomes. The Mixteca Project was executed by CIMMYT's Natural Resources Group (NRG), which studies ways for productively and sustainably managing maize and wheat farming systems, and as a complement is exploring approaches for developing, testing, and promoting adoption of improved management practices.

Alternativas, located in Tehuacan, Puebla, is a private organization that has worked since the mid-1980s to advance rural development in the Mixteca zone of Puebla state and since the mid-1990s in Oaxaca. Its offerings have centered around the cultivation, processing, and marketing of the pre-Colombian seed crop, amaranth (*Amaranthus hypocondriacus*) on around 60 ha with 400 farmers. "Water Forever" has resulted in various water capture, storage, and transport works (dams, small reservoirs, piping systems, among others) and environmental restoration efforts (including soil containment barriers and reforestation). Alternativas has also leveraged government contributions to support amaranth producers, as part of the project. In Oaxaca, Alternativas has collaborated with the NGO *Centro de Apoyo Comunitario Trabajando Unidos, A.C.* (CACTUS). Both NGOs are widely recognized in rural communities and regional institutions.

Participatory action research: Why is it needed?

One of the most severe criticisms of traditional research is based on the contention that its products have not served the poorest rural farming and indigenous communities. In fact, critics claim that where technology developed via the conventional approach of technology generation and transfer has been adopted, its effects have been either onerous or null, largely for their failure to reflect social, economic, or cultural realities. Approaches that emphasize sustainable development, gender considerations, and participation represent attempts to address the above criticisms, and now comprise essential components of research and development for development agencies, research institutes, and donor organizations, among other actors.

It was in this context that the alternatives of action research and participatory research emerged. Action research is meant to create knowledge to transform and improve a situation (Schmelkes 1991). Participatory research is its complement and, unlike conventional top-down approaches, proposes that the knowledge generated should become the property of all parties involved. This has several implications: such research must address local problems; the community should make decisions about the process; the process should help people to recognize their skills and resources; and external agents should consider themselves both participants in the process and students of it (Hall 1983; Schmelkes 1991). When the two approaches are combined, they give us participatory action research, a form of knowledge generation in which individuals play a conscious role in research to bring about the desired changes in their situation, while working towards a position of self-management (Farrington and Martin 1989; Schmelkes 1991).

In agronomic research, the Farming Systems Research (FSR) approach applied in some research centers emphasized the need to include farmers in research and to learn from them. Both approaches form the foundations of participatory research in agriculture (Farrington and Martin 1989: Nelson 1994).

Examples of participatory research in agriculture can be found in projects involving the Centro Internacional de Agricultura Tropical (CIAT), the Tropical Agricultural Research and Higher Education Centre (CATIE), and the Programme to Strengthen Agronomic Research on Basic Grains in Central America (PRIAG), in collaboration with the Center for International Cooperation in Agricultural Research for Development (CIRAD).

One of the best known and most firmly established of these is CIAT's project for participatory research in agriculture. Its strategy of designing experiments that follow scientific guidelines has won it recognition from the scientific community. It has also been a fruitful source of information and manuals, including a series of 13 handbooks for local farming research committees and the Manual for Evaluating Technology with Producers (Ashby 1998). Its strategy involves establishing local research committees, with members elected by the community, to design a research program of interest to the community. An expert assists the committee members, among other things offering them a menu of options.

The PRIAG-CIRAD initiative is known as the farmer experimenter (FE) strategy. Like CIAT's, it involves forming committees, but in this case the members are recognized farmer experimenters from the community, assisted by a facilitator (Hocdé 1997; Hocdé 1997b; Espinosa 1997).

The CATIE approach—with a rich, versatile methodology that allows small farmers to make decisions at different levels—places great importance upon agreements between small farmers, facilitators, and experts as a means of implementing strategies tailored to fit each case. This approach has been used mainly in integrated pest management (comments made by Falguni Guharay, a researcher in the CATIE Integrated Pest Management project).

Other interesting approaches are the farmer-to-farmer projects implemented by several NGOs and Bunch's proposal for participatory development. In 1982, Bunch proposed a strategy based on getting people enthusiastic about solving problems. The idea is to start with simple things and small-scale experiments, not to give things away without payment, and to let people do things for themselves. His view is that development is a process through which people learn to play a constructive part in solving their own problems.

The leader in participatory diagnoses in Mexico is the Environmental Studies Group (GEA), which has produced several manuals. Also, important is the Regional Centre for Cooperation in Adult Education in Latin America and the Caribbean (CREFAL) for its work at the forefront of popular education. In the 1960s other attempts at participatory development and popular education were made at various places in Mexico.

More recently in Mexico, the Rockefeller Foundation has sponsored several research and development projects with a participatory approach. Among them is the Small Farmers Experimentation Group, whose members study strategies to complement research undertaken by farmers. Among other schemes with a participatory approach are those of NGOs such as GIRA, CESE, and PAIR in Michoacán, Mexico, and the farmer experimenter methodology proposed by the Mexican Institute of Forestry, Agricultural, and Livestock Research (INIFAP) in Guanajuato.

In each case, the idea is to encourage small farmers to take part in producing, evaluating, adapting, and diffusing farming technologies that suit their local circumstances. The level of decision-taking by the farmers, the acquisition of knowledge and methodological processes, and the interaction between small farmers and experts vary greatly according to a project's aims and purposes, the type of organization promoting it, and the training given to the experts and facilitators.

Farmer Experimentation: Issues

Participatory farmer experimentation is an innovative strategy that complements and is an alternative to conventional research for evaluating, adapting, and disseminating farming technology. It can be defined as a process in which small farmers, whether individually or as a group, consciously decide to test a technical option to improve food security and quality, production conditions, and income, or to cut production costs.

As part of the above, small farmers analyze, plan, and carry out actions aimed at improving their lot. External agents may play a role, complicating matters for farmers, since it means that agreement has to be reached on objectives, aims, contributions, and an agenda.

As pointed out by Valverde et al. (1996), an FE process without the presence of an expert occurs spontaneously whenever a farmer attempts to take control of his immediate environment in response to his everyday needs. In such cases, the process differs from a conventional one because, instead of being scientifically controlled, it is shaped by the farmer's aims and not bound by conventional criteria or methodologies (e.g. it almost always lacks a simultaneous check and homogeneity), and evaluation is based on observation. One of its weaknesses is the lack of systematization and the fact that its findings are usually transmitted orally.

Although experts introduce a methodology that simplifies the farmer's complex reasoning, they complicate the farmer's timetable by adding to work (e.g. diagnosis, recording data, and documentation). What is gained by the farmer in this process? Scientific knowledge that can strengthen his methods, experimental designs, results, and the scaling up and out of results.

When external guidelines are adopted for an experiment, the farmers' agenda will necessarily be limited by the external organization's agenda. External agents must understand that, if they are to make a real contribution to the process of local management, decisions have to be taken jointly and fairly: they must be facilitators, not manipulators.

Farmer Experimenters: Revitalized Managers of Farming Technology?

Rural communities have no lack of enthusiastic small farmers open to innovation; people capable of studying problems and alternative solutions and of using their own judgment to evaluate them. These small farmers are known as farmer experimenters (FE; Hocdé 1997). They are constantly trying out new seeds or new tools, and it is not surprising that their findings are often later adopted in formal science. The output-oriented approach once taken by some scientist long ignored ecological interactions and the marginal environments where large numbers of poor farmers struggle to survive. Areas where environmental conditions were once good are now suffering from pollution and falling production. Faced with this situation, we can try to restore the ecology in these areas or turn our efforts towards increasing the production of food in marginal areas. However, in the latter areas, there is a risk that the fragility of the ecological interactions may trigger irreversible environmental degradation.

In this scenario, farmer experimenters are social actors who are aware of their problems, needs, limitations, and social interactions. They can contribute on more equitable terms to the generation, evaluation, acquisition, and dissemination of technology that is in keeping with their situation. This may at times conflict with scientific and governmental views about the modernization of agriculture, but it may also provide pointers to the kind of technology that scientists ought to be generating for small farmers.

Farmer experimentation can complement or serve as an alternative for conventional research to test, adapt, and promote adoption of agricultural innovations. Farmer experimenters are perfectly capable of posing questions and identifying problems for study, formulating hypotheses and possible solutions, and testing these using their own criteria. The participation of external agents adds to the process of agreeing on objectives, on a program of activities, on specific contributions by participants, and on possible follow-up (how outputs are used; evaluation of contributions, outputs, or the entire process; and the planning and execution of additional research, to name a few things).

The Mixteca Project: A Participative Research Approach

Participatory and action research approaches, together with sustainability and a gender focus, have taken their place as integral components of modern agricultural research and development and are generally required in any project proposal. Participatory research in particular responds to the failure of conventional development and transfer approaches to reach resource-poor farmers in marginal areas with options relevant to their social, economic, and cultural conditions. The aim is to foster the participation of peasant farmers in the generation, testing, adaptation, and adoption of agricultural technology relevant to the local context.

Farmer Experimentation in the Mixteca Project: An Overview

The Mixteca Project centered on farmer participation and the interactions between farmers and researchers and extensionists (Fig. 4) to identify and analyze problems and test solutions. Many project resources were invested in motivating and empowering farmers in ways applicable for addressing any local problem they choose, as active participants in change to improve their surroundings. Project researchers served as catalysts, assistants, and resource persons in each step of the process (occasionally even as mediators in conflicts within and among communities). Funding agencies and other external institutions contributed information, “venture capital” for experiments, and other forms of support.

An historical account of the process. The first major step was for the institutional participants to decide upon a program, a central theme, a strategy, and the communities in which work would take place. The chief guidelines were to protect biological diversity, respect local practices and agroecosystems, avoid use of agro-chemicals or maize seed introductions, focus on organic agriculture, and strictly respect the communities and Alternativas’ work with them. Regarding site selection, care was taken to ensure that they embody contrasting circumstances and be representative of the region, so that methods and results developed as part of the project might apply widely throughout the Mixteca. After this, participants visited the proposed communities to reconnoiter and assess the possibilities for work there.

The second major step was to obtain the agreement and active participation of the communities themselves. In three of the communities (Lunatitlán, Nochixtlán and Zapoquila) the project was initially presented to farmers who were growing amaranth with the support of Alternativas. They later participated in discussions with local authorities to plan meetings in which the proposed work was presented to the entire community. In the meeting, approval for the project was sought from the local assembly. At the end, farmers who were interested in participating came forward and helped set a date for a subsequent “diagnostic” meeting (Fig. 5).

During the CA and OA phases, project researchers described to farmers the strategy envisioned, from initial diagnostic workshops through farmer experimentation. Farmers’ roles as key agents in the process and, later, as knowledge disseminators were emphasized, as well as researchers’ chiefly support functions. It was clearly stated that any potential solutions for testing should respond directly to farmers’ needs; for this, they learned the watch-phrase “can you eat it or sell it?”. Project implementers described participating institutions as “additional partners” whose objectives for this project would be brought in line with the farmer needs identified and who would provide technical support and limited funds to carry out experiments. Finally, it was suggested that achievements and profits from project activities be leveraged to scale benefits up and out, via the obtention of credits or other forms of external support.

During November-December 1998, project researchers conducted diagnostic workshops with participants from the three communities mentioned above. Methodological tools employed included climate and cropping calendars, trend diagrams,[1] descriptions of soil types, a listing of potential problems, and field visits. Problems identified were analyzed as to their causes and prioritized, after which possible solutions were examined. In the diagnosis with organizations (OA) in the second year, project technicians defined actions to address the agricultural constraints identified. These included greenhouses, drip irrigation, cultivation of vegetables and production of mushrooms.

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[1] Graphs of production levels over several years based on farmers’ observations and local “memory.”

The menu of technical options was enriched by contributions from 1) local proposals from the diagnostic workshops; 2) scientists who visited the region; 3) a visit of farmers to research centers and other farmer participatory research sites in Mexico; 4) technical courses and workshops for farmers on topics of interest relating to the problems identified.

To help farmers decide which technology to investigate, exploratory meetings were held in individual communities and, subsequently, priority setting and technology selection workshops attended by participants from all three communities. Among other things, participants were able to weigh the relative merits of the most attractive options, applying the following criteria:

- The extent of use of local resources.
- The availability of the required information and materials.
- The cost of applying the option.
- The amount of work needed to apply the option.
- The risks involved.
- The ease of learning the option.
- That the technology offer several benefits of value.

For each criterion, participants scored the proposed options on a 1-4 scale. The options with the highest scores were deemed the most acceptable. Finally, the farmers themselves gathered in their individual community groups and, in the absence of the project scientists, drew up a list of the technologies they were interested in studying.

The next step was to define and plan farmers' experiments (EC). During the previous steps, researchers had outlined some of the principles of scientific experimentation and their purpose. It was recognized, however, that farmer experimenters have their own aims and methodologies and that, for the purposes of the Mixteca Project, scientific methods would be adapted to or simply complement farmers' own approaches. With this in mind, farmers were queried about their conceptual framework and experimental methods, using the following questions:

- Why conduct a given experiment?
- Where should the experiment be conducted?
- How should the experiment be carried out?
- How do you determine if what you are testing is actually *not* better than farmers' normal practices?
- How do you share what you have learned with others?

From there, the following steps were followed to design the experiments: 1) analyze the results of the priority setting workshops or previous local experiments in the community; 2) planning and design; 3) follow-up and evaluation, with visits to individual and group plots; 4) evaluation workshops; 5) exchange of impressions among farmer-experimenters.

Project scientists suggested comparing each test with a simultaneous check and uniform management of the checks and all experimental treatments, conducting both in the same types and slopes of soils and under the same conditions. The project scientists visited experiments and took note of farmers' comments to obtain complementary information. The information was used to plan subsequent experiments.

Technical support from the project came in the form of information on participatory techniques to facilitate decision-making and priority-setting, mediation in conflicts, and assistance in recording data. The project also provided material support to establish experiments. During the second cycle of experiments, each group of farmer experimenters also received a small amount of risk capital or money to be managed as revolving funds.

Finally, project scientists also conducted experiments that either complemented those of farmer-experimenters or tested other promising options. Farmers were encouraged to visit the plots, give their opinion, and test options of interest in their own fields.

Early Achievements and Disappointments

Institutional cooperation

During August-October, 1998, Alternativas and CIMMYT discussed project objectives and strategies. The differences in institutional philosophies and approaches were strongly evident in the inability of the two organizations to agree about a clear philosophy or approach for the project, as well as concerning their respective roles or overall project supervision. Alternativas' portrayed CIMMYT as an "imperialistic" promotor of seed + chemicals technology in a fragile, marginal area surrounded by an ecological reserve (a national cactus preservation zone), while Alternativas felt they stood for ecological conservation and practices associated with organic farming. The debate concerned the use of improved seed, conservation tillage, external inputs, and maize-based agriculture. Alternativas' proposal centered around amaranth and downplayed the importance of the maize-bean-squash intercrop. Moreover, their water harvesting proposal as part of "Water Forever" was not aimed at providing irrigation for agriculture.

Given the above differences, it was agreed that activities should follow these guidelines: 1) ecological diversity should be protected and fostered; 2) local practices and production systems should be respected; 3) the introduction of improved seed and the use of agro-chemicals should be avoided; and 4) the communities and the community projects of Alternativas should be respected. There was disagreement, however, regarding the Mixteca Project's basic methodology as well. On the one hand, Alternativas was demanding a participatory approach, but on the other they balked at a methodology that invested farmers and communities with increasing levels of control over choices of technology. For example, the NGO opposed the diagnostic workshops, because their personnel already "knew" the problems. Alternativas also disagreed with the practical training offered to farmers on preparing organic fertilizers and insecticides, because their technical staff were already familiar with the practices. (In this case it was evident the knowledge had not been effectively transferred to the communities.) In the end, an agreement was reached with Alternativas whereby the Mixteca Project would:

1. Identify the main constraints to agricultural productivity and sustainability
2. Identify diverse technical options that could help improve production and sustainability.
3. Evaluate through farmer experimentation the performance of the options identified.
4. Support Alternativas with strategic research on amaranth and serve as a liaison between the NGO and research centers.

The central theme was to be the conservation and rational use of water and soil, as a way to deal with the semiarid conditions and the degradation of agricultural land. A complementary study on male-sterility in amaranth was proposed, as well as an analysis of the region's prevalent soils. It was also agreed to conduct participatory rural assessment workshops to analyze problems and possible solutions together with farmers, as well as to continue with farmer experimentation as an approach for testing, adapting, and promoting technology.

Regarding site selection, it was agreed to work within a micro-zone where the NGO had recently begun activities and wished to strengthen them. The addition of altitudinal and soil diversity as criteria resulted in the selection of sites representing a broad range of conditions found in the region.

Notwithstanding, the initial polemics created an atmosphere of uncertainty and friction that left Alternativas unsatisfied.Finally, in mid-1999 Alternativas officially abandoned the project, although in practice the NGO had stopped participating as of the beginning of that year.

Community cooperation

Obtaining the approval and cooperation of the communities for the project was an important accomplishment. Initial contact was established with Lunatitlán, Nochixtlán, Zapoquila, and Fronteras. This was accomplished with the help of the leaders of Alternativas' amaranth program, who put the Mixteca project representatives in touch with authorities in each community. It was the decision of the leaders of the local amaranth project to present the project proposal to local authorities, and this turned out to be crucial. They in turn authorized a community assembly, which allowed the Mixteca scientists a public forum to present the project to all community members, rather than linking with a select group and possibly creating or exacerbating rivalries and divisions in the community. The assemblies were arranged as part of the normal program for such events, and were well attended, but only 10-15 farmers from each community finally ended up participating in the Mixteca Project. Participants in the meetings were mostly men in the first three communities. When work began with the farmers' associations, women from those groups also began to participate in project activities.

Farmers in two other communities approached by project representatives were disappointed upon learning that they would receive only technical support and small financial contributions for experimentation. They had expected more extensive financial support or credits, a full-time technical advisor, and assistance in marketing products. For this reason, they declined to participate.

Project communities

The first cycle of experiments was established in Lunatitlán, Nochixtlán, and Zapoquila, located in a small watershed about 35 km long in the north of the Mixteca Oaxaqueña. The villages cover a range of environments typical of the Mixteca (Table 2; Fig. 1).

In early 2000, project participants linked with other organizations and communities that had ties with the original three, as a way of fostering exchanges of experiences and technologies. Two communities from the Mixteca Alta, a highland zone (2,200 masl, dry temperate climate) were chosen (San Francisco of the municipality of Teopan and La Labor of the municipality of Asunción Nochixtlán); and one womens community group from the Mixteca Baja.

Despite the differences in environment, the communities share certain features: scarce precipitation, mostly in rainfall from June to September with a dry spell from mid-July to mid-August; thin, shallow soils, with medium depth topsoil only in riverain areas and valleys; a pH of 6.5-8.0; and scant vegetation (bushes, cactus, spiny plants, grasses, and some oaks only at higher altitudes).

The maize-bean intercrop predominates, followed by bean, wheat, and amaranth monocrops. Cultivation is done by hand and with draft animals, with little use of agro-chemicals. The following are more detailed descriptions of the communities.

Table 2. Characteristics of the primary project communities.

Community	Altitude (masl)	Maximum temp. (°C)	Minimum temp. (°C)	Annual rainfall (mm)	Soil types
Lunatitlán	1,580	27	12-15	625-700	Regosol and Litosol
Nochixtlán	1,810	24-27	12	700	Feozem and Litosol
Zapoquila	2,020	24	12	700	Litosol and Rendzina

Source: Maps of the Mexican National Institute of Statistics, Geography, and Informatics (INEGI).

Lunatitlán belongs to the municipality of Santiago Chazumba. It has a semiarid, subtropical climate and receives the least precipitation (250-400 mm per year) of any of the project communities and a long mid-season dry spell (as much as 45 days) during July and August. It is chiefly hillsides with small plateaus. Soils are very thin, shallow (10-20 cm), gravelly with rocky outcroppings, and of medium texture. Inhabitants practice few soil or water conservation measures. Cactuses constitute the predominant vegetation, with some shrubs. Amaranth and red prickly pear cropping has recently been promoted. The mainstays of the local economy are goat herding and gathering prickly pears (*pitayo* and *jiotilla*); basic grain production provides only partial subsistence. The locals say that half the original population now lives in other cities; these emigrants send back money to supplement their families' incomes. Inhabitants are well-organized and receptive to external assistance. They have maintained good relationships with a range of outside organizations and obtained various types of aid. Alternativas has worked intensively in the community on amaranth cropping and in the construction of small dams as part of its ecological restoration efforts.

San Juan Nochixtlán also belongs to the municipality of Santiago Chazumba. The climate is semiarid subtropical with 350-550 mm of precipitation per year. The landscape is rugged, with a small valley. Farm fields are located at the bases of hills and bordering a seasonal stream; soils are of medium depth. Most plots feature the beginnings of soil conservation works. The maize-bean intercrop again is predominant, and provides food security for most inhabitants in those grains. Land tenure conflicts are a serious problem in the community; some farmers conserve the traditional concept of communal land (these are most often linked with the political opposition), while others consider themselves as small-holder owners of the land they farm. Mixteca Project participants came principally from the former group.

Zapoquila is the seat of a small municipality. The climate is semiarid temperate, with frosts during October-February. Rainfall oscillates around a mean of 550 mm per year, with a mid-season drought during much of July-August. Vegetation includes oak trees with scrub grasses and shrubs. Some inhabitants keep peach and avocado orchards. Farm soils are shallow and of medium-to-fine texture. There are soil conservation works that have been abandoned. In addition to maize and some wheat, farmers raise cattle and goats. During the project a dispute arose for the mayor's position; the resulting discord hampered efforts to promote farmer experimentation. Most notably, the village has lost half its population in the last 15 years.

Ayuquililla is situated in the extreme northwest of the Mixteca, in Huajuapan District. At 1,550 meters above sea level (masl) and with an annual precipitation of 400 mm, the village has a semiarid subtropical climate. The predominant vegetation is composed of low trees, shrubs, and cactuses. Farmers' fields are located on hillsides, small plateaus, and at the foot of hills. Soils are of shallow-to-medium depth and intermediate texture. Ayuquililla is home of the association "*Mujeres Productoras de Amaranto* " (Women Amaranth Farmers) comprising 22 women and 2 men. It is part of the group of villages supported by the non-government organization CACTUS, which promotes amaranth cropping and small development projects. The *Mujeres* project was established in the mid-1980s as part of a political party and received diverse support at that time in return for its political commitments and activities. In recent years, the group has successfully compartmentalized its productive and political activities.

Two other important non-government organizations in the region are the *Centro de Desarrollo Integral Campesino de la Mixteca "Hita Nuni",* A.C. (the Hita Nuni Center of Integral Peasant-Farmer Development; CEDICAM) and the *Unión de Pueblos Choco Mixtecos,* A.C. (the Union of ChocoMixteco Communities, UPCHMAC).

CEDICAM was founded in 1982 and works out of Nochixtlán to promote integral rural development through alternative technologies that raise living standards in Mixteca communities. Its activities in more than 20 villages include soil and water conservation, reforestation, community health, and agricultural production. It has a solid base of farmer-promoters who follow a strategy described as "farmer to farmer." It is recently reorienting its aims toward outputs that allow promoters and farmers to improve their incomes.

Constituted in 1991 with seven member communities, UPCHMAC has its offices in San Francisco Teopan, Coixtlahuaca District in the northern zone of the Oaxacan Mixteca. Its objectives include integrated conservation and improvement of soil, water, and forest resources, as a platform for enhancing agricultural productivity, food security, and household incomes.

Both organizations work in the Mixteca highlands, a zone with elevations from 2,000 to 3,000 masl, rugged terrain, and severe erosion. Annual rainfall is around 600-700 mm, with the typical July-August drought and strong risk of frost from October to February. Oak trees and scrub grass dominate the vegetation. The main cropping pattern is maize in association with climbing bean, but wheat and bean monocultures are also grown, and UPCHMAC participants grow amaranth. This area contains small valleys that are important wheat cropping environments, and peach and apple trees are dispersed throughout the region. Some farmers even use tractors for plowing. Both organizations also obtain government support, financial and of other types, for the communities where they work. Neither has professional or technical staff; rather, their extension activities are carried out by their teams of farmer-promoters.

Results of first diagnostic workshops

From the various sessions with farmers, the problems that emerged as priorities were lack of moisture and land degradation (Table 3). The lack of moisture stems from a perceived decrease in rainfall and the mid-season drought; both have intensified, in farmers' estimations, as a result of deforestation, climate change, and pollution. The low moisture retention capacity of the soil was also cited.

Table 3. Main constraints to agriculture in the Mixteca region of Mexico: results of diagnostic workshops with farmers in three communities, 1998.

	Lunatitlán	Zapoquila	Nochixtlán	Number of times mentioned
Lack of water	CC, T, L	CC, CC2, T, L	CC, CC2, T, L	11
Degraded soils	CC2, T, L	CC2, S, L	CC2, T, L	9
Diseases and insect pests	L	CC2, L	T, L	5
Erosion	CC2, T	-	T, L	4
Heavy, compacted soils	CC2	S, L	CC2	4
Lack of residues	CC2	CC	CC2	3
Frost	-	CC, L	-	2
Hillsides	-	T, L	-	2
Weeds	-	CC2	L	2
Late planting	-	L	-	1

CC = climate calendar; CC2 = crop calendar; T = trend line; S = soil type; L = list of constraints.

Soil degradation is attributed to soils' shallowness, the reduced application or complete absence of manure, general erosion, the abandonment of conservation efforts, and monoculture (understood here as continual maize-bean intercropping).

Interactions with NGOs

Members of the organizations with whom the Mixteca Project interacted were already familiar with the constraints to agricultural productivity in the region, and were engaged in activities to address some of them, especially through options to increase incomes and which complemented their other activities. Echoing Alternativas' concerns, both CEDICAM and UPCHMAC objected to the use of improved maize varieties from CIMMYT, on the basis of 1) their confidence in the qualities of local materials developed through farmer selection; 2) the difficulties of producing or obtaining hybrids locally and the likelihood that hybrids would perform poorly in the Mixteca; and 3) the possibility of introducing transgenic germplasm that might contaminate the local varieties.[2] But both organizations were willing to extend the portfolio of their activities beyond simple water conservation and basic food self-sufficiency and, building on these, develop technology options that could generate income for farmers. For UPCHMAC this meant a serious water harvesting and utilization proposal, while CEDICAM was open to testing diverse technical options to enrich its offerings.

Farmers' participation in the analysis of constraints showed their knowledge of their environment and its conditions, as well as the causes of some problems. However, other constraints went completely unmentioned, including soil compaction, soils' low organic matter content and poor water capture and retention capacity, over-tilling, and over-grazing.

Building on farmers' perceptions and observations of researchers and participants from the other organizations, a diagram hypothesizing constraints and their interrelationships was developed (Fig. 6). After the diagnostic workshops, important questions were 1) how best to address the constraints clearly identified by farmers and 2) how to help farmers recognize problems that did not emerge from the workshops, define their causes, and take proper action. The methodological tools of the Mixteca Project scientists allowed them as outsiders to understand the local circumstances and vision quite well, but the farmers seemed to weary at times of discussing in detail problems that were common knowledge for them, and some farmers even withdrew from the process, complaining that there was a lot of talk with few clear proposals or offers to show for it. It also may have helped for the scientist leading the workshop to emphasize more the importance of going through the diagnostic exercises to get farmers to buy into the process. Collaboration with the NGOs was easier in this sense, since there was no need to organize groups nor define a set of problems. Working with them, however, did entail adjustments in the project's ideology, methods, and agenda of activities.

The most effective tools in the workshops were the crop cycle calendar, the trend graphs, and the list of problems. Through the calendar, participants clearly identified points during the crop cycle when problems occurred or certain actions were required. Using the list of problems gave a firm sense of priorities by providing a head count of the farmers who felt one or another of the problems to be paramount and also revealing the diversity of constraints. Finally, this approach also got around the hurdle of discussions and outcomes being dominated by the most eloquent participants. The trend line also depicted the constraints of greatest concern and helped participants to consider their changes over time. When using these three tools, the recommended

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[2] CIMMYT never aimed to introduce hybrid maize specifically, but rather discussed offering a selection of both hybrids and open pollinated varieties that were deemed most adapted to the conditions of the Mixteca, a region where the center had never worked before. Finally, CIMMYT does not conduct field tests of transgenic maize nor promote this product anywhere in Mexico.

order is first to work through the problem list, then to draw up the crop cycle calendar to indicate when constraints are felt and when corrective actions should be taken and, finally, to construct the trend line.

Elaborating Technical Options

Lack of water and soil degradation were identified as the region's priority problems. To address them, project participants developed a menu of technical options based on or modified according to 1) the opinions farmers expressed during the diagnostic workshop, 2) the opinions of scientists and other specialists working in the region, 3) the ideas of farmers after visits to research centers and farm fields in central and northern Mexico, 4) knowledge gained by farmers in training workshops, and 5) close collaboration with the other organizations mentioned in this document.

Proposals from individual villages

The initial proposals for technology amendments from the three main villages are largely aimed at correcting soil degradation, and less at addressing the lack of water (Table 4). This outcome reflected farmers' clear sense of impotence on the water issue, as well as their realization of the significant (perhaps prohibitive) costs of any sustained and effective actions to locate or capture additional water for agriculture.

Table 4. Proposals from farmers in three villages of the Mixteca region of Mexico for addressing the region's main constraints to agriculture, 1998.

	Lack of water	Soil degradation
Lunatitlán	Reforest	Use farmyard manure Organic fertilization Build barriers and drainage Rotate crops
Nochixtlán	Build water retention barriers Level land Select seed of local maize	Select seed of local maize Organic fertilization Use green manures Reduce erosion
Zapoquila	Select seed of local maize	Organic fertilization Restore stone/brick barriers

There were several proposals for organic soil fertilization, and a general rejection of mineral fertilizers due to their high cost, the risk of losing the investment they represent in the case of crop failure, and a farmers' lore about it weakening the soil. Following in frequency were suggestions for barriers to guard against erosion and help capture and retain water, efforts that farmers felt would entail high labor costs. Finally, there were proposals to select and test seed of local maize for drought tolerance and early maturity.

Farmers and others working in the NGOs had very specific interests and higher expectations than independent farmers. They were particularly interested in the capture and efficient use of water through systems such as small-scale irrigation, greenhouses, and nurseries for forest and fruit plants. Another interesting idea was that of actually improving local maize varieties for tolerance to drought and to low nitrogen and iron soils. With CACTUS and its women's group, the focus was on garden vegetable production through small-scale drip irrigation systems and technical support to systematize the production of oyster mushrooms.

Input from scientists

A 1999 brainstorming event in which scientists from participated helped broaden the menu of options and identify fragile vs potentially more productive environments (Table 5). This group gave greatest importance to organic fertilization, crop diversification, forage crops, and summer pasturing. Interest or preference was evidenced among other ways by the number of researchers at the discussion table for a given topic.

Composting or fertilization were seen as options for intensifying production. The participants pointed out the need to evaluate potential mineral and organic sources of nutrients. Potential areas of intensification identified included riverain areas and terraced lands with medium depth topsoils. Regarding farmers' reluctance to use mineral fertilizers, it was suggested that ways be sought to reduce risks of crop failure, increase the efficiency of use, evaluate doses and mixtures, and analyze profitability prior to introducing the option. Emphasis was also placed on use of organic fertilizers, possible sources being a range of manures, human excrement, plant biomass, and household residues. Composting and vermicomposting were mentioned as potentially useful. Regarding some of these suggestions, it was mentioned that goat manure is becoming scarce and expensive, use of biomass in composts would compete with its use as forage, and use of human excrement goes against local culture. Training was suggested as a way to deal with these constraints.

Table 5. Pooled suggestions and priorities of scientists from various Mexican and other research and extension organizations* regarding technology options for addressing the main constraints to agriculture in the Mixteca region, Mexico, January, 1999.

Topic	Number of proposals	Preference
Fertilization and composting	6	10
Cropping system diversification	8	8
Forages and summer pasturing	10	8
Live fences and cover crops	6	3
Irrigation	5	1
Maize germplasm	4	0
Reduced tillage + mulching	4	0
Cropping system intensification	3	0
Social processes	3	0

* Included participants from USDA-Agroforestry; the Mexican non-government organizations Alternativas, A.C., and *Centro de Apoyo Comunitario Trabajando Unidos,* A.C. (CACTUS); the Mexican National Institute of Forestry, Agriculture, and Livestock Research (INIFAP), and the International Maize and Wheat Improvement Center (CIMMYT).

More diversified cropping was cited as a way to diversify and increase income, strengthen food security, buffer risks of crop losses, and enhance system sustainability. Among the approaches considered were intercrops, annual and seasonal rotations, and the introduction of new food and forage crops. Examples include maize-medicago, forage legumes, renewal of a more diversified maize-based intercrop (including maize-amaranth-bean-groundnut), and orchards. Regarding forages and summer pastures, there is a need to evaluate pastoral areas and do a resource balance to identify opportunities for intensification through cultivation of trees and grasses and to set aside areas to provide firewood, biomass, etc. Implementing many of these ideas sustainably would require prior, communal agreements and training and education for farmers and other inhabitants. Other technologies discussed included biomass banks, improved productivity in summer pastures, reforestation with multi-purpose trees, protection of natural vegetative regeneration, and more efficient use of available forages.

Proposals for intensification of riverain and terraced lands included increased fertilization, irrigation, use of improved germplasm, and cropping diversification. There were also proposals for environmental restoration and enhancing agrosystem sustainability (barriers, diversification, rotations, cover crops, mulching, agroforestry systems, etc.). Finally, there was the recognition of the need for a systems approach that took into account socioeconomic and cultural factors.

Tours and farmer exchanges

Farmer tours and exchanges provided an opportunity for project participants to see firsthand the application of some of the technical options previously only discussed. Most of the sites visited were chosen in part for their similarity to the Mixteca project locations — information generously provided by CIMMYT's geographic information systems and modeling laboratory (Fig. 7).

An extensive visit was made to the arid central Mexican states of Guanajuato, Michoacán, Querétaro, and Zacatecas. The practices Mixteca farmers found most interesting were the use of mulches, drip irrigation, soil conservation techniques, reduced tillage, selection among local varieties, animal-drawn planters, integrated pest management, and dry latrines.

Some farmers had a chance to interact with members of the "Farmer Experimentation Group" (*Grupo de Experimentación Campesina*; GEC), comprising farmers and scientists who discuss participatory approaches and share technologies for organic and sustainable agriculture. Other farmer organizations visited included 1) the *Unión Tzansekan Tinemi* in Chilapa, Guerrero State; 2) *Maderas del Pueblo del Sureste,* A.C., in Zanatepec, Oaxaca; and 3) *Desarrollo Comunitario de Los Tuxtlas* in San Andrés Tuxtla, Veracruz. Through exchanges with farmers in these organizations, the Mixteca farmers learned about green manure cover crops (GMCC), live fences, soil conservation measures, herbal medicine, household and botanical insects, organic fertilizers, family orchards and, more recently, alternative feeds for sheep and the processing of farm products.

Training workshops

The training workshops helped fill gaps in farmers' information on key topics and establish the importance of the technical proposals (Table 6). There were workshops on preparing organic fertilizers

Scientists and farmers coincided regarding the primacy of water and soil as concerns but, whereas the scientists proposed forest regeneration through community-level changes in the management of goat herds, farmers were not interested in this topic (Table 7). The scientists also proposed little regarding nutrition, health, or agricultural machinery. Farmers said nothing at all about nutrition or health. The group GEC made moderate contributions with regard to soil and pest management. Their most significant input was fostering the communication and analytical skills of farmers and generally encouraging them to open up to new ideas, all of which helped improve the process of local management.

Choosing options for experimentation

In March 1999 interested farmer experimenters reviewed a list of 32 technical proposals, aided by a printed guide describing possible advantages and

Table 6. Training workshops for farmers in the Mixteca region, Mexico, 1999-2000.

Workshop topic (Date)	Technological themes	Ecological themes
Organic fertilizers (April, 1999)	Preparing, applying organic fertilizer	Soil microfauna, macro and micronutrients, composts (soil, leaf).
Seed selection in local maize varieties (November, 1999)	Selection procedures.	Selection criteria.
Management of insect pests (April 2000)	Pest management; control measures; experimental strategies; botanical insecticides.	Pests vs beneficial insects; Life cycles of pests.
Soil management (May 2000)	Management activities; live fences; level curve; intercrops and rotations; GMCC; foliar fertilizers; mineral fertilizers.	Soil components; cause-effect relationships; macro vs micro nutrients; soil life forms; erosion.
Irrigation (November 2000)	Drip irrigation; aspersion; irrigated crops.	Infiltration; water retention capacity; evaporation.

disadvantages of each (Table 8). Participants for Lunatitlán decided to focus on fewer options, to increase the likelihood of success in their efforts.

In this first attempt to select technology options for experimentation, the most attractive options appeared to be the introduction of new crop varieties, legume green manures or cover crops, organic insecticides, and trees for use as green manures and forage (Fig. 8).The use of mulches and hydrogel proved less interesting to farmers. Regarding desirable qualities for new crop varieties, farmers cited early maturity, adaptability to the region's peculiar (and difficult) rainfall distribution pattern, and tolerance to drought and low soil fertility. In the case of maize, varieties should have large, white grains and produce abundant foliage for forage.

Regarding mulches, cover crops, and green manure/ forage trees, farmers said that they would probably serve chiefly as forage. Farmers from two of the villages expressed interest in irrigation systems, and it was agreed that they should visit other places where different systems were being used to study their feasibility for the Mixteca. Finally, farmers expressed interest in obtaining a small combine for wheat, given that some had left off sowing the crop because of the difficulties of harvesting it.

Farmers from the three villages next gathered in a workshop to prioritize the technical options in which they had previously expressed interest, applying a range of criteria and scoring the options on a 1-4 scale

Table 7. Contributions (number of proposals) to technical options from different sources in the Mixteca Project.

Technology	Farmers	Scientists	Farmer tour	Workshops	GEC*
Water management	6	12	17	13	2
Soil conservation/use	5	22	18	15	16
Pest management	3	5	9	6	6
Nutrition and health	0	0	6	12	5
Alternative crops	6	5	13	4	3
Goat herd management	0	10	8	1	4
Agricultural machinery	2	3	3	1	1
Reforestation	2	3	3	1	2
Maize germplasm	2	4	1	2	3
Social process	0	3	0	0	0
Methodology	0	3	0	0	0
Total	26	70	78	55	42

* Grupo de Experimentación Campesina.

Table 8. Number of farmers from three villages interested in specific technological options for addressing water and soil conservation and management concerns in the Mixteca region of Mexico, 1999.

	Zapoquila (n = 10)	Nochixtlán (n = 8)*	Lunatitlán (n = 9)*	Total number of proposals
Maize varieties	6	3	7	16
Cover crops	1	4	4	9
Organic insecticides	2	3	-	5
Composting	3	-	-	3
Trees (green manure, forage)	1	3	-	4
Live barriers	1	1	-	2
Hydrogel	-	1	-	1
Live fences	1	-	-	1
Groundnut	-	-	2	2
Red wheat	-	-	1	1
Experiments proposed	15	15	14	44

(Table 8). The event was facilitated partly by members of three NGOs (GIRA, CESE, and PAIR) that work with farmers in Michocán state, Mexico, and representatives of Alternativas also participated.

The options of green manures and green manure/forage trees caused a bit of controversy. Farmers doubted whether they would actually be able to fulfill both aims, given the likely intensity of their use as forage, and feared the competition for scarce moisture and nutrients between legumes and the main crop.

Notwithstanding, by the end farmers had developed a list of 70 possible experiments, and 10 other farmers expressed a desire to learn breeding techniques for improving their local varieties (Fig. 9). The most attractive options were use of organic insecticides, a liquid compost known as supermagro for foliar application, the introduction of new maize varieties, and improvement of local maize varieties. Options such as composting, supermagro, and organic insecticides caused considerable excitement, especially since the workshop featured practical demonstrations on organic fertilizers and organic insecticides. In the case of new maize varieties, interest was in part based on the assurance of obtaining seed. The lesser interest in trees, live fences, and green manure cover crops was due in part to the above-mentioned questions regarding their efficacy and the fact that any benefits would not be evident in the near term.

The prioritization workshop was a group exercise involving participants from all three communities, but the actual choice of experiments occurred individually and separately within each village (Table 9). Thus, the program of experiments eventually conducted reflects only indirectly the group's pooled interests, which were likely affected by influential farmers, scientists, and NGO representatives attending the workshop.

For the participating organizations, the technologies of greatest interest were those that complemented their existing offerings, some of which had already been tested previously in the three main villages. UPCHMAC had a well-defined vision on water issues, comprising the following key practices: construction of earth-and-rubble dams; capture of water from springs and marshes; clearing of silt and sediments from existing dams; exploring the construction and use of concrete reservoirs and similar storage technologies; recycling of bath and wash water; and the efficient transport and use of irrigation water. Their soil conservation recommendations emphasized testing of

Table 9. Summary of the priorities and number of experiments proposed by farmers during a workshop to address water and soil conservation and management concerns in the Mixteca region of Mexico, 1999.

	Zapoquila (n = 7)	Nochixtlán (n = 8)	Lunatitlán (n = 11)			
Technology	**Priority rating***	**Number of proposal**	**Priority rating**	**Number of proposals**	**Priority rating**	**Number of proposals**
Organic insecticides	20.5	4	18.0	8	20.0	2
Forage trees	21.0	0	19.0	1	-	0
Improving local varieties	22.0	0	16.0		-	2
Composting	17.5	4	19.0	8	-	8
Green manure trees	16.0	0	19.0	8	-	0
New maize varieties	15.5	4	15.0	1	23.0	5
Supermagro**	-	4	-	8	-	1
Live fences	19.0	1	-	8	-	0
Live barriers	15.0	1	10.0	0	-	0
Cover crops	18.0	1	9.0	0	13.0	0
Hydrogel	-	0	9.0	0	-	0
Mulches	17.0	0	-	0	-	0
Total # of experiments	-	19	-	42	-	18

* The proposals were scored on a 1-4 scale; ** A liquid compost for foliar application.

green manures and cover crops. Finally, they recommended careful documentation of experiences with the above, as a source of feedback for promoters. CEDICAM envisioned its linkages with the Mixteca Project more in terms of testing complementary technologies, the results of which would feed into its own promotional activities.

Despite the opposition of Alternativas and UPCHMAC to introducing improved varieties of maize, farmers judged it prudent to test a series of genotypes of maize, wheat, oats, and triticalle, well as drip irrigation and greenhouses. There also arose the idea of establishing fruit tree nurseries as agroforestry systems and to strengthen erosion control ridges.

CACTUS in particular linked with the women amaranth producers of Ayuquililla in support of their experiments with drip irrigation for garden vegetables and, later, legumes for grain production and weed control, and the introduction of sweet potato and yucca.

Evolution in farmer attitudes. During this stage, some of the farmers who had begun participating during the earlier stages dropped out or decided to participate simply as observers. Causes cited by other farmers included the absence of monetary remuneration or gifts or clear, quick solutions to farmers' concerns. Added to this were disputes relating to land tenure and politics.

Partly to avoid conflicts stemming from the above or from partners failing to follow through on commitments, it was agreed that farmers should conduct their experiment individually, rather than in groups. Only in Lunatitlán did farmers decide to organize in groups for certain experiments.

Project scientists fostered and supported the prioritization and selection of options for experimentation. Among other things they developed and distributed to all participants information sheets summarizing advantages, disadvantages, and requirements (labor, materials, other) of the various options. They adopted a passive role at actual decision-making points in the process, leaving this to farmers individually and at the community level. As a recommendation for future exercises of this type, the team of scientists need to meet beforehand to agree upon how they will facilitate discussions, the aims they seek, and the criteria they will suggest.

Farmer Experimentation in the Project

Farmer experimentation in the Mixteca Project was just that. Farmers themselves designed the experiments, provided most materials and labor, with limited support from the project in certain areas (equipment, seed, technical guidance), and evaluated their results.

Key suggestions from project scientists regarded uniform management and use of checks. These were afforded in prior discussions with farmers of experimental principles, with the following basics:

- Experiments are conducted to address and (hopefully) solve a problem.
- Experiments should be located where access is easy and other farmers can see them.
- The experimental plot should be relatively small, so as to reduce risks, and on land that is uniform in soil and other properties, or similar to plots where replicate or check experiments are conducted.
- Desirable characteristics for an experiment are that it be 1) easy for most farmers to conduct; 2) comprehensible to farmers; 3) conducted using typical management practices; 4) provide results that improve food security, incomes (via enhanced productivity and/or reduced costs), and/or the environment.

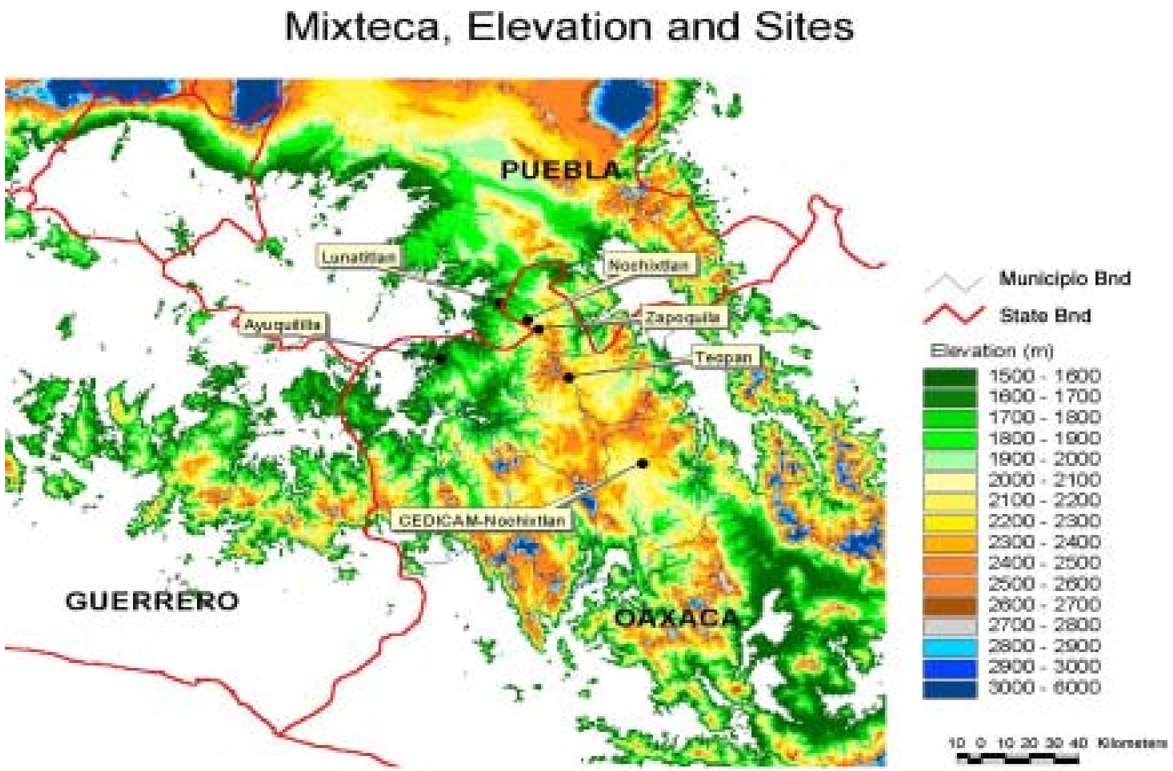


Figure 1. The Mexican Mixteca: altitude ranges and project work sites.

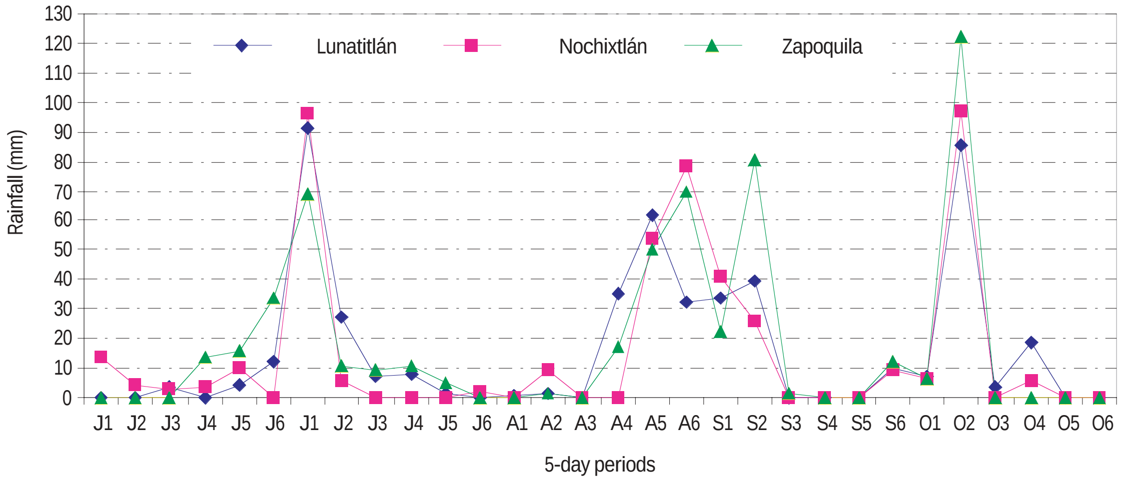
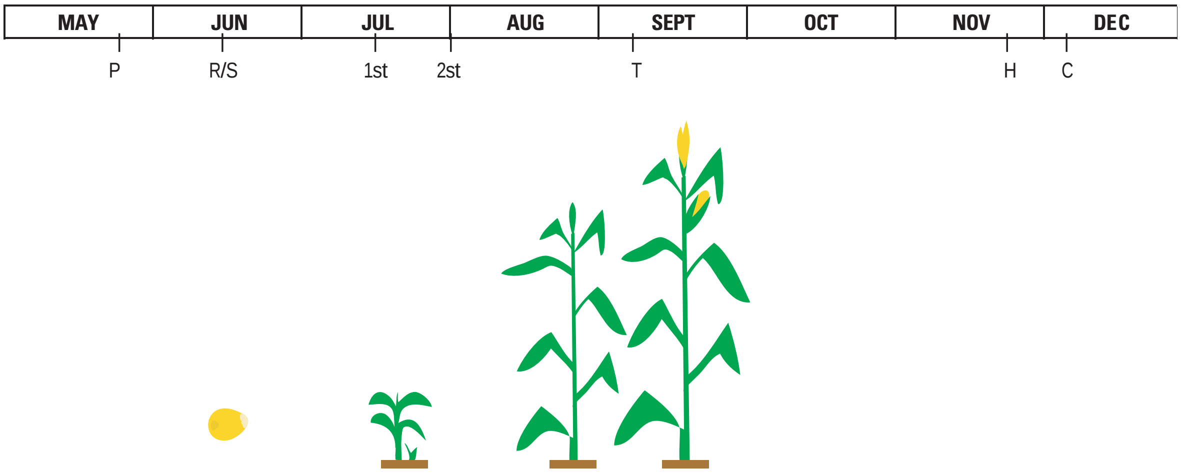


Figure 2. Rainfall patterns in three project sites, the Mexican Mixteca, June-October 1999.



Key

P = plowing; R/S = forming rows/sowing; 1st weeding ; 2nd weeding; T = thinning; H = harvest; C = chopping residue

From left to right:

1) Sowing (15 June is mean date).
2) Intense plant growth, up to around 40 days after sowing.
3) Appearance of flag leaf (i.e., onset of reproductive stage).
4) Male flowering, around 65-75 days after sowing.

Figure 3. Typical cropping calendar for the Mexican Mixteca.

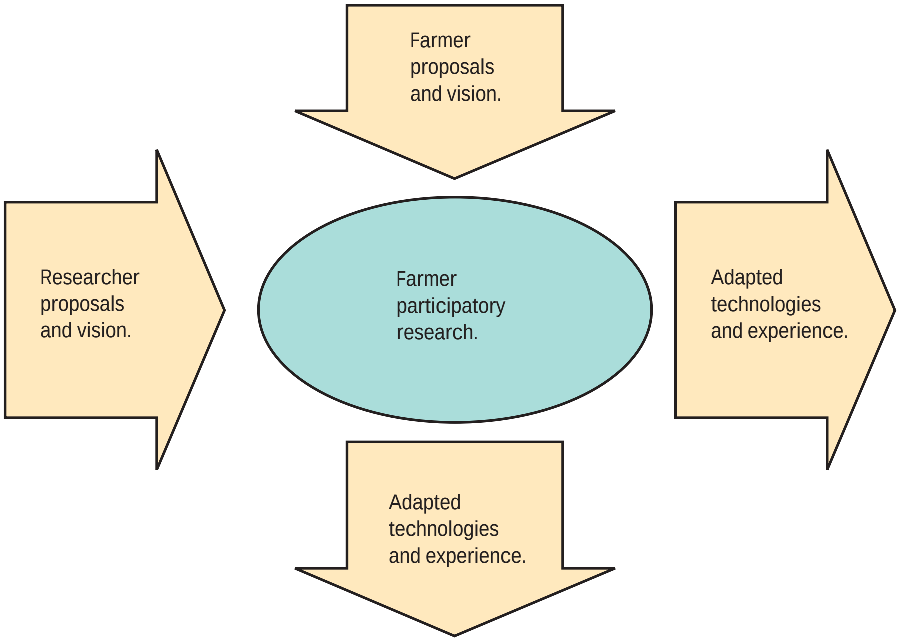
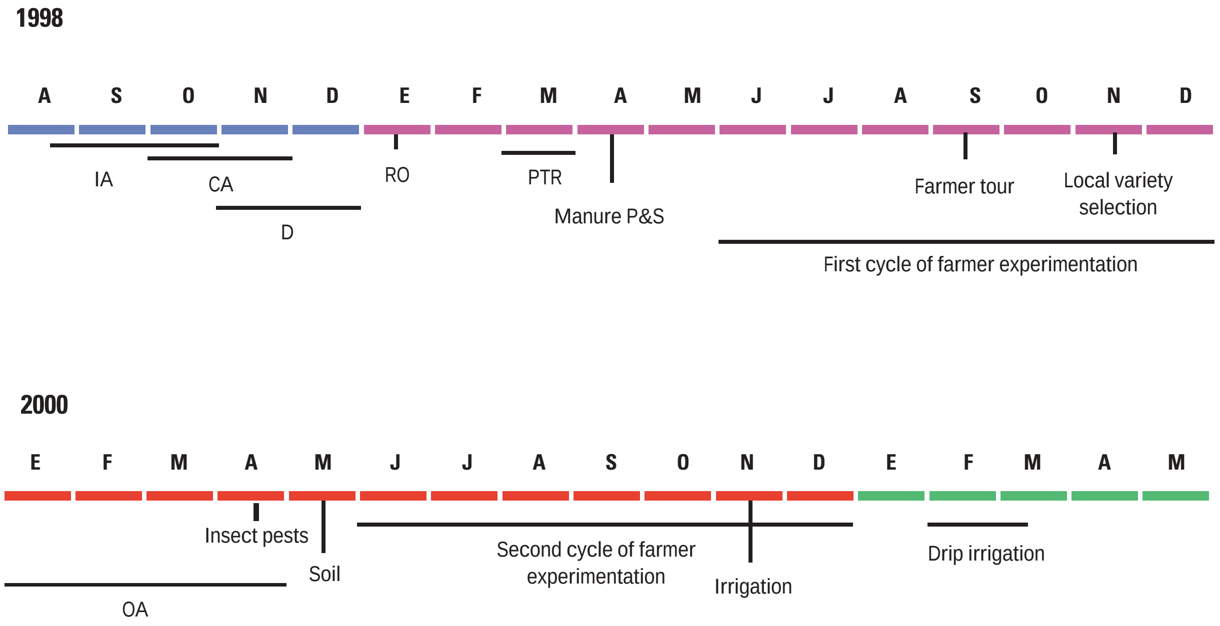


Figure 4. General scheme of farmer-researcher interactions.



IA - Institutional agreements
CA – Community agreements
D – Participatory diagnostics
RO - Researcher options

PTR - Prior technology review
P&S - Prioritization and selection workshop
OA – Agreements with other organizations

Figure 5. General scheme of project activities, the Mexican Mixteca, 1998-99.

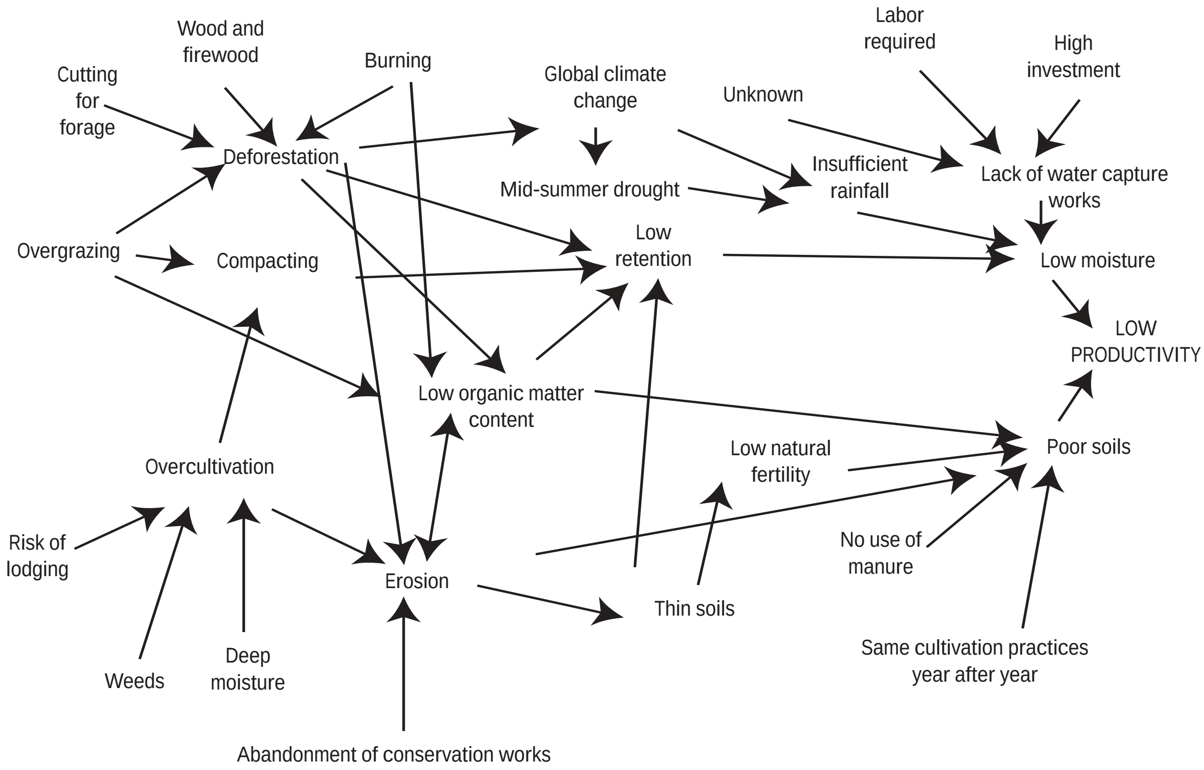


Figure 6. Hypothetical cause-effect diagram of agricultural productivity constraints in the Mexican Mixteca.

Figure 7. Other locations in Mexico with environments similar to those of Nochixtlán village, the Mexican Mixteca.

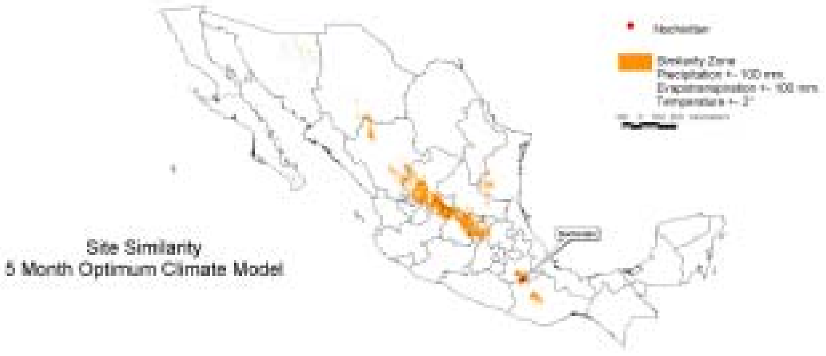


Figure 8. Relative interest of farmers in a range of technology options, the Mexican Mixteca, April 1999.

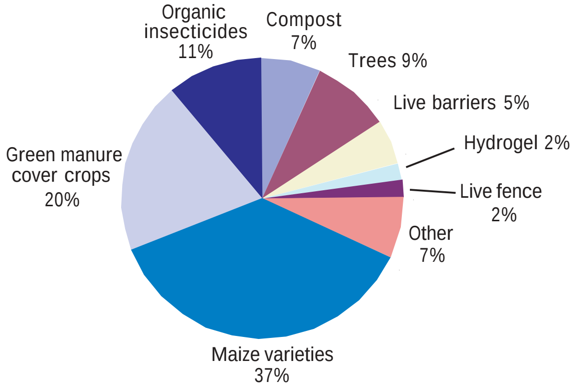


Figure 9. Technologies of interest identified in a priority setting workshop with farmers, the Mexican Mixteca, April 1999.

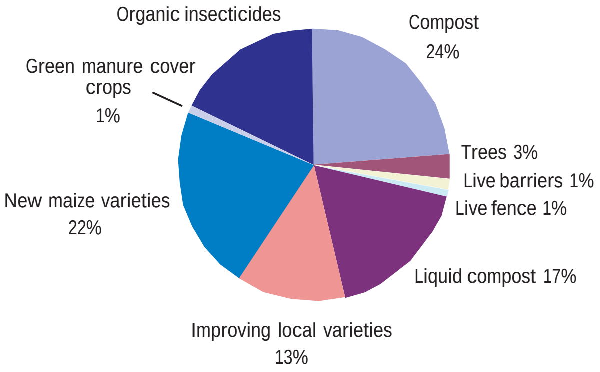


Figure 10. Technologies that farmers tested, the Mexican Mixteca, 1999-2000.

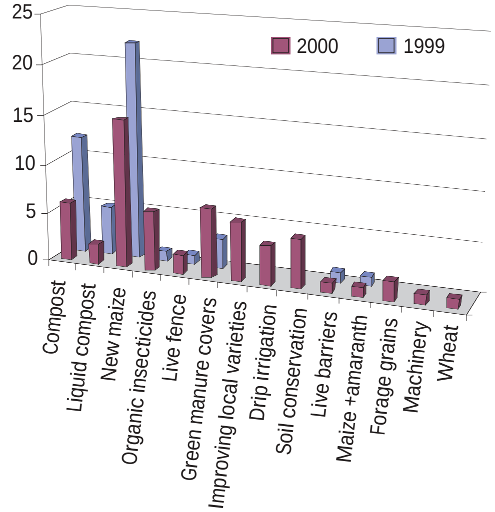
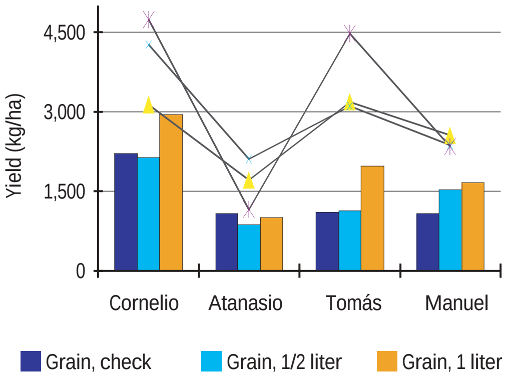


Figure 11. Effects of applying the liquid compost "supermagro" on maize, four farmers, the Mexican Mixteca, 1999.



- To be able to judge the effectiveness of an experiment and obtain useful results, farmers should record observations and measurements, and these should be compared with something else (i.e., a check).
- Experimental plots should be managed in exactly the same way as the "check" plots, with only one factor (i.e. the experimental one) being variable.
- Finally, results should be shared with peers in the village and the region. Three approaches were suggested 1) conducting experiments where they would be in view of other farmers; 2) organizing farmer visits to the experiments of other farmers; and 3) organizing periodic, project-wide events where farmers present their results to peers and discuss their experiences.

After the first cycle of experiments, participants gathered once more to discuss the outcomes and principles of experimentation, in view of their experiences. A key conclusion was that "…a poorly conducted experiment does not help…on the contrary, it causes distrust of the work" and of experimentation in general.

The most challenging aspect to deal with was that of measuring variables, given that farmers had previously judged technologies chiefly on visual observation. To date few have become involved in yield assessments carried out by scientists in the project. Another point of contention is the size of experiments, because some farmers have viewed large experiments as a source of financial support.

Participating farmer experimenters

Most of the first cycle of experiments were begun between June and August, 1999 (although testing of CIMMYT maize varieties began in March that year). The second cycle of experiments was established mainly in the rainy season of 2000, although testing of drip irrigation began in March or April. In January 2001, drip irrigation experiments were expanded.

The progress reports that follow refer mainly to activities in Lunatitlán, Nochixtán, and Zapoquila, whose continuous participation allowed analysis during the entire project.

Their was a steady attrition of farmer experimenters throughout the project (Table 10), starting from 49 in the exploratory stages and 44 in the diagnostic workshop. As mentioned, farmers observed that this was due chiefly to the lack of gifts or direct monetary remuneration and the extra work involved. Disputes in at least two communities limited the addition of new participants.

Collaboration with the NGOs began in 2000; their contributions will thus be mentioned separately. There were 22 women from the group in Ayuquililla, 8 promoters in both CEDICAM and UPCHMAC. In 2001, a group of 8 women from Nochixtlán began participating. Members of the NGOs have had similar experiences with desertion, but were eventually able to form work groups that included open and progressive farmers willing to make a commitment and contribute their own resources.

Table 10. Number of farmers involved in the Mixteca Project.

	Organization	Diagnostic workshops	Priority setting	Experiments, phase I	Experiments, phase II
Lunatitlán	12	12	9	10	8
Nochixtlán	17	12	8	8	7
Zapoquila	20	20	7	7	6
Ayuquililla	-	-	-	-	22
CEDICAM	-	-	-	-	8
UPCHMAC	-	-	-	-	8
Totals	49	44	24	25	59

Each farmer-experimenter established from one to four experiments in the first cycle (Table 11). In the second cycle, 81% of the farmer-experimenters maintained the same number of experiments. A few participants conducted more than four, a fact that could be judged a success for the project, but made them hard to follow-up and monitor. Finally, it is interesting to note that, although the number of farmer-experimenters dropped 16% from one year to the next, the number of experiments increased 32%. This resulted from four participants who ran between 5 and 11 experiments each.

Participation and experiments were better planned and designed during the second cycle. Farmer-experimenters used checks more often, either simultaneous (side by side) or temporal (comparing different years). Less well understood were the concepts of keeping experiments small to limit risks and cost, or growing trials and checks in uniform environments.

Experiments by topic

The range of technologies tested also increased year by year. In 1999, experiments were conducted on 8 technologies; in 2000 the number reached 14 (Fig. 10; Table 12). This was due in part to the inclusion of new options about which farmer-experimenters initially lacked information. Farmer interest in each particular option was spurred in a different way. For example, training workshops led farmers to test soil conservation practices (borders, ditches, and contour ridges, selection of local varieties, organic insecticides, and irrigation (experimentation for the latter three of which was expanded in 2001). Direct observation of potentially relevant technologies during study tours fired interest in drip irrigation, vegetable gardening, the animal drawn sowing implement, wheat, and triticale. Legumes received promotion as an option when farmers observed project researchers' trial/demonstration plots. The women farmer-experimenters focused particularly on crops and practices that contributed to family food security, including drip irrigation on small vegetable gardens, mushroom cultivation, edible legumes, sweet potato, jicama, and tomato.

Table 11. Number of experiments conducted per farmer-experimenter in the Mixteca Project.

Experiments	Farmer experimenters 1999	Farmer experimenters 2000
1	12	9
2	8	3
3	2	1
4	3	4
5	-	2
6	-	1
11	-	1
Farmers	25	21
Experiments	46	61

Several technologies were discarded after initial testing, among them highland maize varieties, composting, and organic fertilizers for foliar application. In the case of composts, poor management by some farmer-experimenters resulted in inadequate decomposition, and the failure of the rains in the month following their application reduced or nullified any beneficial effects they might have had on the crop. The liquid compost “supermagro” raised expectations; but its use was limited by the difficulties of making and applying it. The latter was due in part to the unwillingness of some farmer-experimenters to share aspersion sprayers provided by the project. In the second year, funds were allotted for discretionary use by farmers experimenters, and some purchased sprayers. The testing of maize varieties also diminished with time. Grain and forage yields from the improved varieties and hybrids tested were less than those of the local varieties, especially at sites above 1,900 masl. At sites below 1,850 masl, farmers tested varieties derived from local maize genotypes and supplied by INIFAP. Some performed at least as well as the local maize in drought tolerance, grain weight, and quality for use in local dishes, so farmers continued testing them.

With the entrance of new communities and NGOs in the project, interest in drip irrigation and green legume cover crops or green manures increased. The UPCHMAC group helped in structuring and implementing experiments, particularly those involving drip irrigation, white clover, and greenhouses. Members of CEDICAM also tested drip irrigation and small greenhouses, and the potential of maize and wheat varieties.

Technical achievements

Two cycles of experimentation has given a rough idea of the performance and likely adoption of some of the technologies tested. Unlike on-station experiments or scientifically controlled research, in farmer experiments the trained scientist must adapt to actual field conditions and observe results and trends through the lense of farmers' objectives. Thus, results lack statistical validity, but exhibit lots of common sense and reflect a participatory process of learning in action, both for farmers and participating scientists.

This report is based on qualitative observation, together with farmers, of plots, and comparison and discussion among farmers themselves. The latter was complicated by the fact that, even when testing the same technology, two farmers likely varied their treatments or used different checks, and this circumstance was more evident as farmers gained greater control over the experiments and the process. Another source of information were discussions and visits with farmer-experimenters. Yield estimates directly in the field, where farmer-experimenters had supposedly followed standard practices and used a check or some other method of validation, complemented the information gathered in conversations. One novel source of information were direct exchanges of experiences between farmer experimenters themselves, on their own initiative. The following section presents technical advances under the project, briefly describing the technology tested, its source, materials or inputs used for the experiments, results of assessments taken to complement farmers' observations, and a reflection on the knowledge gained and questions requiring clarification.

Table 12. Experiments conducted in each cycle of the Mixteca Project.

Topic	1999 Communities	2000 Communities	Organizations
Compost	12	6	-
Foliar fertilizer	5	2	1
Improved maize varieties	22	15	1
Organic insecticides	1	6	1
Live fences	1	2	-
Green manure covers	3	7	5
Selection of local varieties	-	6	-
Drip irrigation	-	4	2
Soil and water conservation*	-	5	-
Live barriers	1	1	-
Alternative cropping systems	1 maize-amaranth	Maize-amaranth, tomato	Jicama, sweet potato, yuca
Forages	-	2	1
Equipment**	-	1 planter	-
Mushrooms	-	-	1
Wheat and triticale	-	2	1
Totals	46	60	16

* Includes borders, ditches, and contour ridges.
**Interest in the equipment was not counted toward the total, if no experiment was performed. The intent was to identify areas for follow-up.

Soil conservation and improvement measures

Low soil fertility is a chief constraint to agriculture in low-income countries, and it is continually reduced by erosion and the low use or lack of use of organic or chemical fertilizers. Among the options promoted and tested as part of the project during 1999-2000 were various soil conservation measures (borders, ridges, and ditches), fabrication of organic fertilizers (composts, organic fertilizers for foliar application), and use of chemical fertilizers. Testing of the above required farmers to change their work and social routines. For example, conservation measures must be done prior to the cropping season, with an investment in labor during a period when there are normally no activities. Composts and foliar fertilizers must be prepared in February and April, and there are cultural biases against foliar fertilizers whose ingredients include manure or urine.

Compost. Compost is used widely in organic agriculture, representing a useful way to recycle organic residues from many sources. Farmer-experimenters in the Mixteca Project received training on the topic from three NGOs based in Michoacán State. Initial suggestions involved a mixture comprising three parts manure and four parts crop residues (stalks, leaves, husks, etc.), with a small added dose of simple calcium superphosphate. The management proposed involved constant checking of humidity and temperature, with weekly mixing to promote uniform decomposition, for around three months. Experts from the NGOs suggested two applications of 1/2 kilogram per plant — once at sowing and again no later than the first weeding (about 30 days after sowing).

Farmer-experimenters themselves prepared their composts in diverse manners, ranging from following the recommendations to simply piling organic residues into a hole. Diverse as well were the materials used: 1) farm residues, like maize dry matter and cobs and wheat, bean, and amaranth straw; 2) tree residues, including dry and green leaves; 3) goat, donkey, horse, and pig manures; 4) other materials, such as guano, ant nests, ash, simple superphosphate, and ammonium sulphate. Of note is that, even under conditions of such low biomass production, it is possible to find enough organic material to prepare composts; in the case of high-value materials (maize forage), using leftovers from feeding cattle.

Compost preparation lasted from 1.5 to 3 months, with 1 to 5 stirrings to air and moisten the mixture. Several of the ingredients were highly lignified (for example, maize stalks) and, in some cases, had not decomposed completely prior to its use. This was the result of short preparation periods, poor handling (too little stirring or moistening), and use of large pieces andmaterials that resist decomposition (maize cobs, stalks). The poorly decomposed compost posed a risk of N draw-down from the soil around the crop, as it continued decomposition; but yellowing (evidence of N deficiency) in the composted crop beyond levels in the non-composted check was observed in only one field.

Laboratory analyses showed that the composts can provide from 0.87 to 2.43% N, from 1,222 to 9,421 ppm P, and from 5,467 to 14,886 ppm K. They also show that the composts contain more P, Zn, Fe, CU, and S than the goat manure commonly used, and that they also provide more Na and Mn, in some cases. (N, P, Zn, and Fe are the nutrients in which most soils in the project area are most deficient.)

Composts were applied at around 30 days after sowing maize (farmers did not begin preparing their composts soon enough to apply at sowing). This coincides with the date they normally apply goat manure, just before the first weeding. The typical dose was from 0.75 to 1.5 kilograms per plant (from 10 to 12 tons per hectare, at a 62% moisture content). This may seem like a lot, but farmers considered it appropriate, since composting allowed them essentially to “stretch” the amounts goat manure normally available at no extra cash cost. Several farmers applied the compost in the lowest fertility areas of their fields, so in the first cycle of testing there was no statistical difference either for grain (P = 0.45) or dry matter (P = 0.73) yields. The overall mean is biased in favor of applying compost by the case of one farmer who had excellent results (Table 13) but also affected by farmers choosing to apply the compost to infertile patches in their fields. Positive results were due mainly to the use of large amounts (1.5 to 2.0 kilograms per plant) of compost applied and its more advanced state of decomposition. In the first season, 12 farmer-experimenters prepared and applied composts, 7 of whom said they obtained good results, including plant color, stalk thickness, and grain yield. The farmers who did not have positive results saw no difference except for one case, where the composted plants showed clear yellowing due to inadequate prior decomposition of the compost.

In the second season of experiments, farmers felt more confident about applying from 1.5 to 2.0 kilograms of compost per plant, combining this treatment in with those of new varieties or canavalia, and in comparison with chemical fertilizer or guano (Table 14). Grain production was slightly higher in checks in four of the five experiments, and there were contradictory results in another. Nonetheless, all six farmers who tested composting felt that it gave them good results, above all in the second plot of Tomas where the practice had been applied for the second year in a row and plants appeared more vigorous. Compost was systematically used by farmers on areas in their plots that were considerably less fertile than the check plots, and the composted plots eventually caught up with the test plots in fertility.

Table 13. Grain and dry matter production in composting experiments with maize, the Mixteca Project, 1999.

	Grain (kg/ha)		Dry matter (kg/ha)	
Name	**Compost**	**Check**	**Compost**	**Check**
Mario	3,849	2,170		
Atanasio	364	189	609	560
Celestino	545	772	999	1,607
Juan	3,324	3,469	7,379	6,571
Alejandrino	215	226	2,063	1,886
Average	1,659.4	1,365	2,763	2,656
S.D.	1,585.65	1,273.33	2,717.94	2,313.75
C.V.	95.56	93.28	98.37	87.11

Farmer-experimenters sometimes found no advantages from composting because 1) as in the previous year, the compost had not adequately decomposed; 2) a month-long (± 17 July to 23 August) drought that delayed the application of the compost; 3) the major benefits from organic fertilizers begin to appear from the second to the fourth year of use; and 4) the compost had been applied in less fertile sections of the field, compared with the check plots.

These experiences suggest that the compost must be prepared near water, so it can be kept moist, must contain a fair combination of soft and harder materials, must be stirred regularly and completely, must be applied at sowing, and must be prepared starting at least 3.5 months before sowing. These practices avoid problems from N draw-down due to poorly decomposed compost and the risk of compost's benefits being lost due to the mid-season drought.

Table 14. Results of composting in maize, the Mixteca Project, 2000.

Name	Treatments	Grain (kg/ha)	Dry matter (k g/ha)
Zacarías	Check	2,854	3,745
Zacarías	Compost	1,223	2,828
Zacarías	Chemical fertilizer	3,378	5,028
Tomas	V3+guano	1,404	2,243
Tomas	V3+compost	1,496	4,071
Tomas 2	Check	515	4,853
Tomas 2	Compost	671	3,892
Nacho	Local variety + Canavalia	779	2,745
Nacho	Local variety + Canavalia + compost	1,097	4,784
Juan	Check	2,372	5,091
Juan	Compost	3,314	8,459

Supermagro and foliar fertilizers. Supermagro is a liquid fertilizer for foliar application prepared from fresh manure diluted in water and enriched with bone meal, blood, fish scraps (the latter two contributing minerals), and unrefined sugar and milk to stimulate fermentation. This mix is fermented anaerobically for about 1.5 monthsAnalysis showed little N in supermagro, but that it contained micronutrients generally lacking in local soils. Other organic, liquid fertilizers suggested by farmer-experimenters include fermented, human urine and an infusion prepared from manure.

Supermagro was an idea of the Michoacán NGOs in 1999; the suggestion for urine- and manure-based liquid fertilizers emerged from discussions with a regional organization with which the project collaborated in 2000. All three were initially rejected, partly due to farmers' lack of familiarity with foliar fertilizers and partly due to a lack of sprayers. Farmers found supermagro hard to prepare and some of the ingredients hard to obtain. The thought of using human urine caused distaste. Thus, in 1999 only five farmer-experimenters applied supermagro, and only two in 2000. There were three cases of farmers planning to apply urine- and manure-based liquid fertilizers, but no applications were actually made.

In 1999, Supermagro was applied to maize around 55 days after sowing, after the second weeding. One liter of supermagro was dissolved in nine liters of water, and this mixture was applied from once a week for three weeks. In 2000, farmers made from four to six applications per crop cycle starting around 30 days after sowing, often in tandem with composting.

Of the five farmers who applied supermagro in 1999, four observed positive effects, including improved plant vigor and color, better grain filling, and heavier ears (Fig. 11). During harvest, the benefits of applying supermagro were confirmed: there was a statistically significant difference from the check for grain yield ($P = 0.057$) but not for dry matter ($P = 0.527$) in 2000, both farmer-experimenters observed a positive effect, but there was no measurable increase in yield.

Farmer-experimenters found that a liter or more supermagro to nine liters of water gave the best results and that it was important to make weekly applications starting at early stages of crop development. The farmers who did not experiment with supermagro expressed reservations about the benefits reported, and were generally disinclined to try foliar application fertilizers, suggesting the need for much further study and promotion.

Chemical fertilizer. Chemical fertilizer in combination with organic fertilizer can improve productivity, but is generally rejected by the organizations with which the project collaborated, farmers often lack the cash to purchase it, and the risk of losing their investment when drought kills the crop provides an added disincentive. At the time of the project, only 3% or fewer of the farmers were applying ammonium sulphate or urea alone or together with 18-46-00 in amounts anywhere from 50 to 100 kilograms of commercial product per hectare on the least fertile areas of the field. There have been only two experiments involving soil applications of chemical fertilizer and one involving urea applied to the leaves. This is partly because farmers already know that use of fertilizer produces nearly immediate results, which was the case for the two experiments where fertilizer was applied to the soil.

Soil conservation. Conserving soils is one aspect of soil and fertility management to improve productivity. With help from CEDICAM, the project promoted the construction of ditches and borders, but achievements were few: of the 21 farmer-experimenters, only 2 built borders as a result of the project promoting this practice, and 1 farmer built a ditch-border and 2 others made contour ridges in 2000. This response is similar to that in four of the project villages where SEMARNAP and Alternativas have promoted the construction of borders and ditches through 2,500 peso (US$270/ha) subsidies. Achieving the aims of these efforts will require close linking of all stakeholders and tying soil conservation to projects or activities that bring tangible economic benefits to farmers.

There seems at least to be a widespread recognition of the problem. The most acceptable options for farmers appear to be composting, conservation works, and use of chemical fertilizers. However, acceptance is limited, so further development testing, and promotion are required. Chemical fertilizers are costly, seen as a risky investment where drought occurs, and suffer from a folk impression of weakening the soil. Organic fertilizers are nearer to farmers' daily experience, since they already apply manure. Constraints to the use of organic fertilizers include the low availability of biomass, the work needed to prepare them, and, sometimes, cultural beliefs. The work of farmer-experimenters can serve other farmers in the medium and long terms, if the current trend of emphasizing improved yields continues.

Water conservation and use

Farmers see water as the key productivity constraint in their systems. After an initial feeling of helplessness, organizations and villages are exploring diverse options. The Mixteca Project promoted discussion and diverse options for capturing, storing, and using water.

Agronomic management of moisture. The most attractive options here were contour ridging, drought tolerant varieties, water capture (springs, bogs, and dams), drip and aspersion irrigation, and use of a plumbers pump. Options that provided promising results in tests on farm include subsoiling, irrigation (Table 15), and mulch applications, on observation plots.

In Antanasio's experiment, subsoiling showed promise for improving water infiltration and yields. Juan also improved yields significantly through use of aspersion and garden sprinkler irrigation. In a 1999 mulching (maize residues) experiment, results for two sites in Lunatitlán were statistically equal (P = 0.09) for grain yield, but numerical analysis showed important differences (Table 16). The best treatment was the combination of 3 tons per hectare of residues plus fertilizer. This could be due to the use of fertilizer, given that the second-best option was fertilizer alone, and the worst mulch alone.

The point of this trial was to see if crop residues used as a mulch could help conserve water and thereby improve yields. In Nochixtlán the analysis of variance showed a statistical difference among treatments (P = 0.03), where the test of means showed the best treatment to be the check, but different only from the treatment involving 3 tons of residue plus compost (Table 17). All other treatments were statistically equal to the best and worst.

Table 15. Results of farmer experiments involving water management in the maize crop, the Mixteca Project, 2000.

Name	Treatment	Yield (kg/ha)
Atanasio	Check	767
Atanasio	Subsoiling	2,318
Juan	Border, no irrigation	1,029
Juan	Border, with irrigation	2,489

Table 16. Grain yield in farmer-run water management experiments, Lunatitlán, Mexico, 1999.

Treatment	Description	Grain yield (kg/ha)
3R75N	3 t/ha residue + 75 units N	1,142
0R75N	O residue + 75 units N	654
0Rcomp	0 residue + compost	499
Check	Check	482
3R0N	3 t/ha residue + 0 units N	476
3rcomp	3 t/ha residue + compost	345

Table 17. Grain yield in farmer-run water management experiments, Nochixtlán, Mexico, 1999.

Treatment	Description	Grain yield (kg/ha)
Check	Check	2,185 A
3R75N	3 t/ha residue + 75 units N	1,387 AB
3R0N	3 t/ha residue + 0 units N	1,262 AB
0r75n	O residue + 75 units N	1,1245 AB
0rcomp	0 residue + compost	1,213 AB
3rcomp	3 t/ha residue + compost	837 B

It is interesting to note that treatment “3rcomp” (3 tons of residue plus compost) gave the lowest yields at both sites. This may be a result of incomplete decomposition of the compost, resulting in a net draw-down on system N, or poor plant establishment in the maize residues.

Experiments in 2000 involving residue, compost, and chemical fertilizers were lost to drought. However, it was observed that compost aided plant germination and emergence, possibly because of its high moisture content. An important factor was its placement at the bottom of furrows. In the words of Antanasio: “Because it was placed in the furrow, it didn’t hamper weeding.”

Other options tested included contour ridging, in four plots. Farmers felt that irrigation was improved throughout these plots (more uniform; no puddles or dry areas) and easier. In other cases, aspersion and garden sprinkler irrigation were successfully adapted for use with maize and triticale on sloping plots.

Water capture works. Water capture and storage are activities that Mixteca farmers, villages, and organizations should surely pursue. Such projects (including building reservoirs, dams, and tapping springs and marshes) generally require subsidies, investment, and long-term support for successful establishment. Although interest is high, the financial and labor investments required have limited efforts to capture and store water.

The organization that has most emphasized the capture and use of water for irrigation, as well as cash cropping, is UPCHMAC. Leveraging their own resources and help from other institutions, they have established modest efforts (stone, cement, and reinforced concrete reservoirs; simple wells) to capture and store water from springs and other sources for use in small fields of maize, vegetables, alfalfa, and orchards. Most recently, they have built a landfill dam at a cost of around 70,000 pesos (about US$7,500), water from which is being used for irrigating maize, vegetable gardens, fields of prickly pear cactus, and a greenhouse for tomato production.

The leaders of organizations and villages have great expectations about rolling soil and water conservation and productive reforestation efforts into designs for more profitable farming systems. Ideas include the use of irrigation and manure for growing vegetables, fruits, or some other commercial crop, as well as live fences, live barriers, water basin reforestation, and more diversified cropping (for example, annuals and fruit trees).

Productivity enhancing options

Initially, technology options in this area centered on soil management, conservation, and improvement. After a year and a half, farmers began to show interest in options that could either contribute to the household economy or diversify their food supply. Thus, they began to explore and adapt options such as irrigation systems, triticale, mushroom cultivation, and grain legumes (which in other contexts might be green manures or cover crops).

Drip irrigation in vegetable gardens. This has been the most widely accepted irrigation system. Farmers first observed drip irrigation during the field tour in Michoacán. They subsequently began to explore the possibilities for adapting the system using local materials. Finally, an regional expert from INIFAP provided training on drip and aspersion irrigation systems. To date the project has established micro-irrigation systems for diverse garden vegetables at more than 20 sites. Initially the idea was discussed with three farmer-experimenters, only one of whom eventually decided to set up a system in 2000. Later, three farmers from Zapoquila became interested and began using the system. Finally, after farmers toured project experiments in the villages, others became interested.

Project participants have worked with two types of drip irrigation systems (Table 18). One known as the “bucket” system, because the reservoir is a 20 liter bucket from which some 30 m^2 of garden can be watered, was acquired from the Kellogg Foundation.

The other system was drawn from INIFAP work in Michoacán, from the University of Yucatán, and from a training workshop. This uses PVC containers or barrels of 100-450 liters, or is connected directly to the municipal water system or drawn from springs. It can cover a crop area from 10 to 144 m^2.

Table 18. Irrigation systems established in the Mixteca Project, Mexico, 2000-2001.

Year	Bucket	Small	Intermediate	Total
Winter 2000	1	4	1	6
Winter 2001	3	11	3	17

The materials used were a combination of special drip irrigation and ordinary plumbing supplies. One problem encountered was the plugging of drip holes. To overcome this, farmers adopted use of a filter (either commercial, or simply a piece of cloth) at the entrance of the drip tubes. Farmers are using phosphoric acid to help purge the system of organic residues; the compound also serves as a soil nutrient.

The irrigated cropping systems were established in mid-January and February. The vegetables sown included squash, cucumber, Chinese coriander, radish, spinach, tomatoes, green beans, carrots, broccoli, onions, beets, chard, and cabbage. The most productive species were radish and coriander. Beets, chard, spinach, carrots, onions, and broccoli also did well. Despite their attractiveness as crops, tomatoes and squash were infested by white fly and viruses and thus did not grow well. Of 21 plots observed in 2001, the water supply in 7 ran out because of poor rains the previous crop season, and animals ravaged 4 other gardens; but output was good in 10 (Table 19).

In the opinion of both men and women farmers, the drip was easy to install and use, water consumption is reduced and it was often possible to recycle water from washing clothes and dishes. The systems used from 21.38 to 31.68 liters/m^2/week, spread across from 1 to 7 applications per week, depending on the availability of water (Table 20). For each square meter, there were nine drip holes, with three hoses (actually, plastic strips) having three drip holes each per 85-100 cm crop bed.

Table 19. Production of vegetables using drip irrigation, the Mixteca Project, Mexico, 2001.

Crop	Days to harvest	Yield/m^2	Unit	Local price (Mexican pesos)	Gross earning /m^2 (Mexican pesos)
Chard	45	7	Bunch	3	21
Beets	80	10	Bunch	7	70
Zucchini squash	40-60	5-8	kg	7	35-56
Pumpkin	35	8	kg	12	96
Coriander	35	16	Bunch	2	32
Chile ancho	-	Looks promising	-	-	?
Green bean	45	4.5	kg	8	36
Cucumber		7	kg		
Radish	30	5-9	Bunch	2.5-4	12.5-36

Table 20. Estimated water use rates in drip irrigation for growing vegetable gardens, the Mixteca Project, Mexico, 2001.

Farmer	Soil type	mL/minute /drip hole	L/hr /m^2	l/wk /m^2	Applications /wk
Juan	Clay	3.67	1.982	31.68	1
Timoteo	Sandy clay	4.4	2.376	21.38	2
Ayuquililla	Sandy	4.57	2.468	30.43	7
Teopan	Clayey sand	4.95	2.673	28.066	3.5

The material investment was roughly 10 pesos (just over US$1) per m^2 (Table 21). Irrigation strip hoses must be replaced each year, although this can be extended somewhat, if care is taken to ensure that the water is clean by the time it reaches drip holes. The remaining components can be used at least three years before replacement. This means that drip irrigation is highly profitable, even if farmers grow only radishes, the vegetable that fetches the lowest market price. Vegetable gardens are an innovation that greatly enhances household food security and the quality of diets. Two groups of farmers have acquired additional materials to scale up drip irrigation cropping and four farmers are already marketing the small amounts they produce.

Greenhouses. Several farmers saw greenhouses on a project-sponsored visit to the Autonomous University of Chapingo, an agricultural research and teaching institution in the state of Mexico. They were particularly impressed by the development and production of tomato and the controlled management used (hydroponia). They judged this to be a viable way to use limited space and water intensively. However, the cost was deemed high. Despite this, the more entrepreneurial farmer organizations took up the idea, building small modules with the most economical, local materials. The first design used 3/8" re-steel bars covered with polyduct and bent to form arches over which plastic sheeting was laid. Another alternative involved the use of 5 x 15 m PTR (a type of metal tube) available in hardware stores in nearby cities. In both cases, the intent was to avoid the elevated costs of commercially-marketed greenhouse structures. With the help of UPCHMAC and CEDICAM, farmers in the project are growing tomato and capsicum peppers in two greenhouses of 5.0-5.5 m x 24 m, built using PTR. Each encloses three or four soil beds 0.85-1.0 m wide. The total cost of the greenhouse and establishing a single crop was 10,000 Mexican pesos (slightly over US$1,000). This is about one-third the cost of a commercially-available greenhouse of similar size (Table 22).

The first of these two greenhouses was built with the help of a local metal worker. A CEDICAM farmer-promoter built the second completely, thus acquiring a mastery of greenhouse construction. Both UPCHMAC and CEDICAM consider greenhouses an important way for farmers to make money, and plan to promote this technology in their respective areas of influence.

In the first season when farmers were learning to grow tomato, they learned that it was necessary to weld the greenhouse infrastructure solidly, for it to be able to support the weight of the tomato plants when grown as single stems. They also found it necessary to try and raise the height of the greenhouses, which are currently 1.7 m high at the sides and 2.7 m high in the center, and to improve ventilation and carefully plan

Table 21. Materials and costs for establishing a drip irrigation system on 140 m^2, the Mixteca Project, Mexico, 2001.

Material	Unit	Cost per unit (Mexican pesos)	# of units	Total cost (Mexican pesos)
450 l reservoir	Piece	$585.00	1	$585.00
Filter	Piece	$120.00	1	$120.00
Clamp 1/2"	Piece	$5.00	4	$20.00
Adapters 1/2"	Piece	$10.00	1	$10.00
Nipple 3/4"	Piece	$8.00	2	$16.00
Adapter 3/4"	Piece	$6.00	1	$6.00
Hose 1/2 “	Meter	$2.00	35	$70.00
Spigot 1/2	Piece	$30.00	1	$30.00
Step down from 3/4 to 1/2"	Piece	$8.00	1	$8.00
Hose 3/4"	Meter	$4.00	10	$40.00
Plastic strip hose w/drip holes	Meter	$1.40	360	$504.00
Total cost				**$1,409.00**

winter management practices. Farmers need to learn to manage the crop at high population densities and using single stems, as well as drip irrigation itself. Being new practices, farmers do not feel entirely comfortable with them. Among other things, to prevent damaging attacks of white fly that occur when farmers open the sides of the greenhouse to cool it, there plans to cover the sides with mesh. Farmers will also use organic pesticides and repellents, because they plan to market the tomatoes as organically grown.

The yields of farmer-experimenter Anatolio Lagunas of UPCHMAC were low and could be improved with better management of the plant, as well as diseases and pests. Produce from the greenhouses has been marketed in neighboring communities, where there is demand for the European type tomatoes that generally go for a high price in local markets and a preference for the organic, "local" varieties. The general demand for fresh produce is driving farmers to channel resources into additional greenhouses and consider year-round relay cropping of diverse vegetables.

Table 22. Materials and costs for establishing a greenhouse with drip irrigation, the Mixteca Project, Mexico, 2001.

Number of pieces required	# of pieces	Unit	Unit cost (Mexican pesos)	Total (Mexican pesos)
9 arcs (6 m each) of PTR* 1"	9	Piece	65	585.00
18 square tubing posts 2 m x 1 1/4"	6	Piece	82.44	494.67
7 bars 1/2" de 5.5 m crossing side by side	3.5	Piece	54	189.00
2 frontal square tube PTR 1"	2	Piece	65	130.00
9 suspenders bars 1/2" de 0.85 m	0.5	Piece	54	27.00
2 long lateral square PTR 1"x 24 m	8	Piece	65	520.00
1 top long square PTR 1"x24m	4	Piece	65	260.00
2 front door with PTR 1" de 1.7 m	0.6	Piece	65	39.00
Support for plastic cover (poly-grap)	81.2	Meter	10	821
Polyethylene UV1 6.2 / 720 above of 26 m	65	Meter	28	1820
Spring poly-grap total	5	Piece	24.38	121.90
2 welding material 2 kg	2	kg	21	42.00
3 hacksaws	3	Piece	12	36.00
6 cement	6	Bag	76	456.00
9 support cable of 28 m	5	kg		0.00
Welding and construction labor	5	Day of labor	266	1330.00
Welder's assistant	4	Day of labor	133	532.00
Construction worker's assistant	2	Day of labor	133	266.00
Structure, subtotal				**$ 7,660.57**
Drip irrigation system:				
1 reservoir 450 litros	1	Piece	900	900.00
Black polyduct of 3/4"	100	Meter	2.5	250.00
Filter	1	Piece	120	120.00
Control valve	1	Piece	45	45.00
Nipple of 3/4	1	Piece	15	15.00
Clamp	2	Piece	3	6.00
Drill bit	1	Piece	12	12.00
Strip hose	216	Meter	1.4	302.40
Plastic tubing	20	Meter	2	40.00
Labor	2	Day of labor	70	140.00
Drip irrigation, subtotal				**$1,830.40**
Forming soil beds, planting				
Preparing raised beds of 22.0 m x 0.85 m	5	Day of labor	70	350.00
Goat manure 20 wheelbarrows full x 4 beds	5	Wheelbarrow		0.00
Tray of 220 tomato plants, Orión hybrid	1	Tray	53	53.00
Tray of 200 tomato plants, Río Fuego variety	2	Tray	17	34.00
Tray of 200 pepper plants, Miahuateco variety	1	Tray	20	20.00
Planting (labor)	2	Day of labor	70	140.00
Sowing, subtotal				$247.00
GRAND TOTAL				**$9,737.97**

* A type of metal tube) available in hardware stores in nearby cities.

The tomato crop was matured early (only two months from planting to first cutting) due to high temperatures in the greenhouse, use of irrigation (even when one farmer preferred to use a garden sprinkler), use of around 40 kg/m^2 manure and raised beds 40 cm high made of a mixture of manure and silt extracted from a dam.

Farmer Anatolio Lagunas' suggestions for improving yields include establishing 5-6 plants/m^2, and working with two stems per plant to ensure high quality fruit. He also suggested intercropping strong-smelling or insect-repelling plants, use of insect traps and a fine-mesh on the sides of the greenhouse. He is convinced that organic methods produce a tomato that is softer, juicier, longer-lasting, and more desirable for consumers. With the information obtained, we expect yields of 6 to 7 kg/m^2, given that only half the production was measured before the project ended (Table 23).

Oyster mushrooms. Crop production throughout the Mixteca may be negligible in dry years. Farmers who are relatively well-off have animals and can use the residues as fodder, but poorer farmers have no such option. Production of oyster mushrooms (*Pleurotus ostreatus*) is one alternative for using crop residues and other farm by-products to obtain an excellent food, generate employment, and make some money. Being saprophytes, mushrooms decompose materials that are rich in lignin and cellulose, substances that cannot be used by other plants or animals. The excellent nutritional quality of oyster mushrooms has led to their being called "vegetarian steak" or "the meat of the poor," and they are used frequently in vegetarian diets. Their protein content is 19 to 25% above that of vegetables, by dry weight, including the essential amino acids lysine and tryptophan. They are low in carbohydrates and high in fatty acids (oleic, linoleic) important for human nutrition (Guzmán et al. 1992).

The members of the Women Amaranth Farmers Group of Santiago Ayuquililla learned about oyster mushroom production from an expert hired by CACTUS to teach them the production process. The Mixteca Project provided "venture capital" and technical follow-up.

The Ayuquililla group started with 22 kg of mycelium distributed in 113 substrate bundles (primarily straw). In 3.5 months they obtained 110 kg of commercial quality mushrooms that they sold to an intermediary in the community for 25 pesos (around US$2.50)/kg. This just covered production costs, and the group is trying to improve productivity and thus turn a profit (Table 24).

The constraints they encountered were cultural (the need to maintain high levels of hygiene in the growing environment), managing the flow of people who came to observe and learn from the group's experience and thus introduced contaminants into the environment, the use of straw contaminated with fungi, the lack of a proper place to grow the mushrooms (they were using an old building), and the lack of money to scale up production. It also appears that the period of darkness was not long enough for proper development of the mushrooms.

Table 23. Data from the greenhouse tomato crop of Anatolio Lagunas of Teopan, Coixtlahuaca, Oaxaca, Mexico, 2001.

Variety	Plants/m^2	3 cuttings* (kg)	Area (m^2)	Production, 3rd cutting	
Bola	9	93.5	24.5	3.816 kg/m^2	0.424 kg/plant
Saladet	6	22.5	7.0	3.214 kg/m^2	0.536 kg/plant
Bola	6	105.1	31.5	3.337 kg/m^2	0.556 kg/plant

* Three additional cuttings are expected that represent half the total harvest.

From this experience, the group has produced a written guide and a home video which, together with several recipes, have become popular in several villages. CACTUS is helping to promote and scale up mushroom production and set up regional marketing channels.

Testing new crops and varieties

Most farmers use seed of local varieties. Only in the valley of Nochixtlán are improved varieties of maize, wheat, and barley used. Most local varieties are highly tolerant to drought and adapted to the region's rainfall patterns and crop management practices. Farmer organizations are opposed to the introduction of improved varieties, for fear of contamination from transgenics[3] and because of the need to purchase external inputs to grow the improved materials.

However, working from the premise that improved varieties could raise productivity without further investment than that of purchasing the initial seed, farmers agreed to experiment with new varieties and crops. In the words of Enrique López of CEDICAM: "We'd like to identify seed options for the rough terrain and depleted zones…we don't want to get rid of our local varieties, because they are our safety net, but we'd like to look at other options…as long as they are not hybrids or, worse, transgenics."

Over 1999-2000 farmers tested CIMMYT highland varieties and subtropical maize from both CIMMYT and INIFAP's Central Valleys of Oaxaca research station. All CIMMYT varieties were open pollinated. During August-November 2000 farmers also tried commercial wheat varieties, CIMMYT triticales, and barley and oats. Finally, over this two-year period farmers observed the performance of legumes known for their qualities as green manure cover crops.

Table 24. Materials, costs of production, and profits from growing oyster mushrooms in Ayuquililla, 2000.

Material	Units	# of units	Unit cost (Mexican pesos)	Total cost (Mexican pesos)
Maize straw	Bunch	50	5	250
Mycelium	kg	22	20	440
Bags	kg	3	50	150
Face masks	Piece	46	1.84	84.64
Chlorine	Liters	10	6	60
Alcohol	Liters	1	20	20
Detergent	kg	1	6	6
Lye	kg	11	1	11
Firewood	Bundle	15	15	225
Subtotal MATERIAL				1,246.64
Chopping straw	Day of labor	4	50	200
Disinfecting straw	Day of labor	4	50	200
Planting	Day of labor	2	50	100
Daily supervision	Hour	90	6.25	562.5
Total LABOR				1,062.50
Partial listing of equipment used				
Nylon cloth	Piece	1	200	33
Casks	Piece	3	100	50
Burlap sacks	Piece	44	2	15
Bricks	Piece	113	1	19
Scisssors	Piece	2	50	17
Mosquito mesh	Meter	4	12.5	8
Subtotal EQUIPMENT				141.83
Grand Total COSTS				2,450.97
Production/Income		110 kg	25	2,750.00

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[3] CIMMYT does not field test transgenic in Mexico.

Introducing new maize varieties. Maize-bean intercropping faces serious, complex constraints in the region, and yields are low, ranging from 0.213 to 3.4 t/ha in good rainy years (Table 25). As described in the beginning of this report, certain soils are extremely difficult (white and shallow soils), while in the clayey and porous soils farmers achieve better yields, especially if they are able to apply at least one irrigation. Yields of maize and bean experiments in 2000 were very low or non-existent due to the drought. (In the beans, the highest yield observed was 0.380 t/ha.)

The plots with the highest potential have clayey, porous soils and are located in riverain areas. But these areas comprise only 5% of the region's arable land. An important yield component was the number of ears with grain (Table 26).

Table 25. Production potential of diverse plots in La Mixteca, Mexico.

			Maize grain (kg/ha)		Beans (kg/ha)
Name	Soil type	Location	1999	2000	2000
Zacarías *	Clay	Valley	No data	3,584	0
Felipe	Red clay	Intermediate	2,167	No data	No data
Juanramirez	Clayey	Intermediate	2,540	No data	No data
Juan_P *	Porous clayey	Intermediate	2,164	3,562	125
	Average		2,290	3,573	63
TomasB	Porous	River bank	2,504	1,236	224
Bernardino	Porous	River bank	3,447	1,537	222
Arcadio *	Porous	River bank	2,545	No data	No data
Willevaldo	Lama	River bank	2,795	1,742	372
	Promedio		2,823	1,505	273
Ivan	Light brown	Intermediate	No data	1,263	51
Mario	Reddish brown	Intermediate	2,994	2,149	244
Atanasio *	Gravelly	Intermediate	1,452	2,394	131
Manuel *	Red	Intermediate	1,763	2,884	0
	Average		2,070	2,173	107
Onésimo_A	Shallow soils	Hilltop	No data	1,516	0
Odilón	Shallow soils	Hilltop	471	0	0
Onésimo B	Shallow soils	Hilltop	360	No data	No data
Urbino S	Shallow soils	Hilltop	610	0	0
Carmelo	Shallow soils Arenosa	Intermediate	444	948.5	32
Jaime	Gravellyshallow soils	Hilltop	No data	981	51
	Average		471	689	17
At_monja	White	Hilltop	498	1,168	84
Celestino	White	Hilltop	430	0	0
Salomón	White	Hilltop	939	No data	No data
Zacarías	White	Hilltop	213	0	0
Felipe	White		No data	121	0
	Average		520	322	21
		Average	1574	1,394	85
		Lowest value	213	0	0
		Highest value	3,447	3,584	372

* Farmers with access to at least one irrigation.

Table 26. Averages for several yield components in farmers' fields, 1999.

Soil type	Plots	Percent of ears	Grain yield (kg/ha)	Residue(kg/ha)	100-grain weight
shallow soils	4	38	471	1,958	22
White	4	39	520	1,506	29
Porous	5	71	2,526	3,476	36
Porous intermediate	5	70	2,108	3,365	33
Clayey	1	72	2,378	4,591	32

Testing maize varieties. In 1999 farmers test six open pollinated varieties (OPVs) from INIFAP[3] and five highland OPVs from CIMMYT. In 2000, another 10 highland varieties (recommended range of adaptation: 2,000-2,400 masl) and 10 subtropical varieties (recommended range of adaptation: 1,500-1,900 masl) from CIMMYT were tested, and the most promising INIFAP materials were replanted.

The new varieties showed good plant vigor from emergence until about one month after sowing. The light green coloring of the introduced plants differed from the purplish-green color of the local varieties at early development stages. About 20 days after sowing, all varieties began yellowing, with longitudinal white streaks along the leaf. The introduced varieties were intensely affected by Fe, N, and S deficiencies. By flowering, the local varieties showed superior vigor — manifest in better color and height. Farmers observed that the new varieties were shorter, earlier-maturing, and more sensitive to soil nutrient deficiencies (Table 27).

Some of the varieties tested in subtropical zones produced more grain than the local varieties, but less fodder (Table 28), and the difference in grain yield was not statistically significant (P = 0.355). Fully 83% of the farmers found the new varieties satisfactory, and felt their performance would improve once they became acclimated to the region. Attractive characteristics mentioned by the farmers included their early maturity, superior grain size and weight, fully filled ears, good flavor, and good quality for making doughs and *atole*, a sweetened drink made from corn. Traits that farmers judged to be poor included the thin stalks, low production of fodder, the yellow color of grain of VC 40, the opaque appearance and poor grain fill of VC 145, and the difficulty of shelling VC 134.

In 2000 neither local nor promising INIFAP varieties produced any grain on several experimental plots in Lunatitlán, due to the drought and late planting from a 45-day dry spell between late June and early August. In the shallowest soils in the plot where some grain was produced, the varieties VC 118 and VC 134 outyielded the local varieties (Table 29). Varieties VC 134 and VC 39 showed their superior potential for providing higher and stable yields in the region.

Table 27. Average and relative grain yield (n=6) in a trial of INIFAP varieties, Mixteca Oaxaqueña, December 1999.

Variety	Average (kg/ha)	Ratio: yield of introduced variety/ local variety	CV
2 VC 39	1,911	1.32	28.25169
5 VC 134	1,894	1.30	37.00245
6 VC 145	1,723	1.19	29.78623
4 VC 118	1,697	1.17	30.77547
3 VC 40	1,684	1.16	28.94365
Criollo	1,451	1.00	27.15986
1 V 233	1,128	0.78	21.49805

Table 28. Residue production in a variety trial (n=4), Mixteca, 1999.

	Average (kg/ha)	Ratio of check	SD	CV
Local check	3,460	1.00	1260.19	36.42
VC 145	2,558	0.74	418.43	16.36
VC 134	2,112	0.61	709.97	33.62
VC 118	1,938	0.56	836.25	43.15
VC 39	1,865	0.54	284.42	15.25
VC 40	1,762	0.51	404.65	22.97
V 233	1,584	0.46	865.09	54.62

Table 29. Performance of INIFAP maize varieties targeted for areas from 1,500 to 1,900 masl, the Mixteca, 2000.

Soil type	INIFAP maize variety	Grain yield (kg/ha)
Shallow soils	VC 134	1,409
Shallow soils	VC 118	1,310
Shallow soils	Local	1,135
Shallow soils	VC 39	446
Lama Porous	VC 145	1,269
Lama Porous	VC 39	944
Lama Porous	VC 134	525
Lama Porous	Local	356
Lama Porous	VC 118	178
Lama Porous 2	VC 134	640
Lama Porous 2	Local 2	589
Lama Porous 2	VC 39	576
Lama Porous 2	Local	474
Lama Porous 2	VC 118	473
Brown	VC 118	1,704
Brown	VC 134	1,324

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[3] The project extends its gratitude to Dr. Flavio Aragón of INIFAPs' Central Valleys of Oaxaca research station, for graciously providing seed.

At one site farmers tested 10 subtropical genotypes from CIMMYT (Table 30) and INIFAP varieties in a porous soil (Poroso 2) of intermediate fertility (Table 31). They were generally shorter than the local and INFAP materials. Variety VC 134 and SC CIM 2 yielded slightly more grain than local varieties. Farmers concluded that the CIMMYT variety was short but produced large ears. The new varieties had poor fodder yields.

The improved highland varieties were inferior to the local varieties in height, vigor, and productivity. They were also more susceptible to drought and soil nutrient deficiencies. Farmers who visited the CIMMYT experiment stations at El Batán, Mexico State, and Tlaltizapán, Morelos State, concluded that the poor performance of the varieties or hybrids was due to their selection in more fertile environments with adequate moisture. Nonetheless, the farmers decided to test the genotypes both years[4], and were particularly interested in the materials developed by the CIMMYT maize physiology group using their techniques for drought and low N tolerance breeding, but they were not available. Farmers Jesús León and Anatolio Lagunas commented: "They put on way too much chemical (fertilizer); their maize is used to this…there (in La Mixteca) only a few farmers use three or four bags per hectare of sulphate and there's no irrigation". Performance of the new varieties during the second cycle of experimentation was similar (low stature, yellowing, poor grain and fodder production) to that in the first, except for variety #6 (Table 32), which outperformed the local variety.

Table 30. CIMMYT maize varieties tested in the Mixteca, 2000.

	CIMMYT highland maize, targeted for 1,900-2,400 masl
1	BA 8987
2	BA8887
3	BA 8687
4	ACROSS 98902/903+N
5	BA98902/903-N
6	CMT 959837
7	(BTVCM.BA92 16 x P87C5F111) x BTVCM.BA92 12
8	(BTVCH.BA92 1 x BA90 5) x P87C5 F111
9	(P87C5 F117 x BTVCM.BA92 34) x P87C5 F176)
10	(BTRL.TLA91A 2-6 x BTCVM.BA92 34) x BTVCM.BA92 23

	CIMMYT varieties, semiarid adaptation, targeted for 1,500-1,900 masl
1	S99SIWQ
2	ACROSS 8567
3	POB.68c1HC179-3-1-2-2-B-2-B-B-B X CML 176
4	CML 176 X CML 186
5	CML 176 X CML 175
6	POB.-42 c9 x POB.-44 c10
7	ACROSS MEXICO 97501
8	ACROSS MEXICO 97502
9	CML 78 x CML 321
10	CML 78x CML 373

Table 31. Performance of SC CIM and INIFAP varieties targeted for areas from 1,500 to 1,900 masl, the Mixteca, 2000.

Soil type	Variety	Grain yield (kg/ha)	Residue (kg/ha)
Porous 2	VC 134	640	1,765
Porous 2	SC CIM 2	640	863
Porous 2	Local 2	589	3,843
Porous 2	SC CIM 7	583	2,784
Porous 2	VC 39	576	1,647
Porous 2	SC CIM 9	571	2,020
Porous 2	SC CIM 8	526	2,020
Porous 2	Local	474	5,490
Porous 2	SC CIM 4	474	1,373
Porous 2	VC 118	473	1,804
Porous 2	SC CIM 3	456	1,235
Porous 2	SC CIM 1	400	1,510
Porous 2	SC CIM 5	342	2,196
Porous 2	SC CIM 6	321	2,020
Porous 2	SC CIM 10	225	1,490

Table 32. Performance of CIMMYT highland maize varieties in a plot of good soil quality and with supplemental irrigation at the Rancho Ramírez, Zapoquila, Oaxaca, Mexico, 2000.

Local variety	Plant height (cm)	Grain yield (kg/ha)	Residue (kg/ha)
6	141	1,423	2,233
Local	165	1,127	5,245
2	120	949	2,009
8	140	948	2,624
5	134	872	2,304
3	108	750	1,991
9	133	723	2,869
4	132	717	1,494
1	118	598	1,992
10	117	554	2,241
7	124	127	1,913

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[4] The decision to test maize varieties was a strategy to obtain or maintain support from CIMMYT, farmers said.

Based on these results, farmers are obtaining seed of INIFAP varieties. There is little or no interest in CIMMYT materials, given their poor performance, but a few farmers have established plots for testing and observing in 2001 some CIMMYT materials suggested by a breeder from the center. Together with this, farmers are beginning improvement of local maize varieties that performed well in trials. Finally, the earliness of some of the improved materials tested – one matured 15 days sooner than the local varieties – makes them attractive for use when planting is delayed by late onset of rains and to improve the efficiency of irrigation.

Triticale. In a September 2000 visit to CIMMYT, Zapoquila farmers saw plots of wheat, oats, barley, and triticale. Young (25 years old) farmer Zacarías Muñoz requested samples of seed. Project technical staff followed up and brought seed to the Mixteca for sowing in November, 2000. Muñoz sowed samples on two-meter beds and in double furrows every 100 cm, applying both irrigation by furrows and aspersion irrigation. The triticale had a good color (it showed no evidence of nutrient deficiencies, it grew more vigorously and taller in furrows, and like oats suffered no ill effects from frost. It matured in 4.5 months, compared with the 6 months required for the local wheat. Muñoz and neighbor Juan Ramírez commented: "This 'wheat' has grain heads twice as big as those of the local wheat; production will be twice as much…, they're all good".

The results obtained by Muñoz and Ramírez (Table 33) show the potential of triticale for the region. Yields ranged from 0.39 to 2.1 t/ha, with the highest productivity from sowing in furrows. Genotypes 2, 7, and 8 were the highest yielding, but farmers preferred genotypes 5 and 9. Farmers are testing the adaptation of these varieties to the conditions of season spring-summer 2001. When project researchers suggested that triticale was a good source of fodder, Muñoz said: "Oats and barley are for fodder, triticale is for tortillas, or maybe we can use it to make flour for bread and cookies. " Ramírez said: "My mother prepared tortillas using this 'wheat' and a bit of maize dough, and they're very tasty and …nice and soft!"

Table 33. Data on triticale trials in Zapoquila, Oaxaca, Mexico, November 2000 – March 2001.

Entry	Plants/ha	Grain yield (kg/ha)
Sown on melgas		
EMS M 83.6039/FAHAD.5	461,207	385
CAGUAN_4/FAHAD_5	512,821	924
150.83/3*FAHAD_5	416,667	854
RHINO 1RS.1DL 3384/2*VICUNA_4	566,667	1075
4411.6/MUSMON_1//FAHAD_8_2	703,704	905
FAHAD_82**2/VICUNA_4		
ALPACA_1/3//ZEBRA 31/CIVET//URON_5	588,235	1028
CIN/PI//PATO/3/BGL/4/DRIRA/5DLF/3/DLF/M2A/SNP//BGL/4/TESMO_1/6/FAHAD_1	1,042,945	979
Sown in furrows		
EMS M 83.6039/FAHAD.5	491,071	902
CAGUAN_4/FAHAD_5	500,000	1464
150.83/3*FAHAD_5	491,071	1513
RHINO 1RS.1DL 3384/2*VICUNA_4	589,286	1094
4411.6/MUSMON_1//FAHAD_8_2	812,500	1108
FAHAD_82**2/VICUNA_4	535,714	696
ALPACA_1/3//ZEBRA 31/CIVET//URON_5	1,812,500	2119
CIN/PI//PATO/3/BGL/4/DRIRA/5DLF/3/DLF/M2A/SNP//BGL/4/TESMO_1/6/FAHAD_1	1,517,857	2079

Wheat. Farmers of CEDICAM tested four commercial varieties of wheat – Rayón, Pastor, Romuga, and Culiacán – during August-December 2000. Although they were unable to estimate exact yields, farmers are sure that Rayón and Pastor had the best grain yields. The experiences of farmers with triticale and wheat led to the design of small threshers especially targeted to farmers with small plots in rough terrain. The difficulties of threshing for many farmers in the Mixteca has caused the disappearance of wheat cropping. Now, with the assistance of a specialist who is designing a thresher, the number of farmers testing wheat varieties has increased.

Barley and oats. As part of the visit to CIMMYT and the experience of CEDICAM, the project obtained seed of barley and oats for use as forage crops. During August-December 2000, a few plots were sown, giving the results shown in Table 34. Oats showed signs of N and Fe deficiencies, when grown in white soils of limestone origin. Green matter production at flowering was good, especially for the Chihuahua variety. More than anything, however, this variety was very early-maturing; therein lies its primary utility for farmers. The oats variety Opalo was late-maturing and thus of little interest. In spring-summer 2001, farmers are growing Chihuahua oats, the barley variety Esmeralda, and commercial triticale, to determine if these crops can tolerate the season’s erratic rainfall pattern.

Legumes. Legumes have been widely promoted in work to develop and disseminate more sustainable cropping systems. They are able to fix atmospheric nitrogen in the soil. They provide a vegetative cover that helps protect the soil from erosion and conserves moisture. Finally, certain legumes provide edible grain or constitute a potentially abundant source of fodder.

In contrast to the humid tropics, where several legumes have shown potential, in the Mixteca farmers were testing species to see if any could grow well enough to be included in production systems there. In spring-summer 1999, a legume observation plot was established. Of the species tested, lablab, canavalia, and pigeon pea grew well at altitudes from 1,500 to 1,850 masl (Table 35).

Table 34. Agronomic characteristics and fodder production of barley and oats, Zapoquila, Oaxaca, Mexico, 2001.

Crop	Time to first cut	Plants/m^2	Plant height	Forrage (kg/ha)Juan R.	Zacarías M.
Barley *Esmeralda*	2 months	200	72	1,538	—-
Oats *Ópalo*	More than de 3 months	120	70	1,932	—-
Oats *Chihuahua*	2.5 months	108	75-86	3,102	2,400

Table 35. Legumes tested in the warm areas (from 1,500 to 1,850 masl) of the Mixteca Region, Mexico, 1999.

Species (common name) and source	Biomass	Seed production	Overall performance
Cajanus cajan (pigeon pea), Chiapas	2*	3	3
Cajanus cajan (pigeon pea), INIFAP-VC	2	3	3
Cajanus cajan (pigeon pea), ICRAF	3	3	2
Canavalia ensiformis (Canavalia), Chiapas	3	2	2
Dolicos lablab (lablab), INIFAP-VC	2	3	3
Dolicos lablab (lablab), INIFAP Sinaloa	3	3	3
Vigna unguiculata (Cachito), Chiapas	2	3	3
Vigna unguiculata (Frijol Chícharo), Acatlán	3	3	3
Crotalaria sp (Chepil), INIFAP-VC	1	3	2

* 1, 2, 3 = low, moderate, and high, respectively.

Pigeon pea was particularly attractive to farmers as a live barrier or monoculture, especially in shallow soils where maize was non-productive. It performed well in these settings and survived from one rainy season to the next. The only criticisms of the genotype obtained from the International Center for Research in Agroforestry (ICRAF) was that it was very late maturing and infested by rabbits, reducing the grain harvested.

Another group of farmers expressed interest in canavalia as an intercrop with maize to suppress weeds or as a green manure, but other farmers saw its lack of edible grain as a serious disadvantage.

Lablab interested farmers because of its good biomass production and, in the case of the genotype obtained from INIFAP-Central Valleys, its early maturity. The black lablab from INIFAP was well adapted to the shallow shallow soils soils. A brown lablab from Chiapas yielded well in soils of intermediate fertility, and could be intercropped with maize (particularly the early-maturing lablab genotype that produces few runners).

Farmers sampled cooked lablab beans at a presentation event in Huajuapan de León, Oaxaca, in April 2001, and noted its somewhat distinctive odor, which differs from that of local beans.

At the highest-altitude sites (1,900-2,200 masl), the most promising species were lablab in spring-summer, and pea, common vetch, white clover, and lupine, either as relays for spring-summer maize or as monocultures (Table 36). White clover and lablab appeared to produce the most biomass; seed production was deemed good in the cases of white clover, common vetch, and lablab. Because this information is drawn from only a single season of observations, more testing is needed to reach reliable conclusions.

During the 2000 rainy season, several plots of legumes were evaluated (Table 32). Farmer Tomás Bautista of Nochixtlán tested a range of legumes, from diverse bean varieties to lablab-maize associations. Regarding the beans, some of which he had brought from as far

Table 36. Legumes tested in cooler zones (from 1,850 to 2,200 masl) of the Mixteca Region, Mexico, 1999.

Species (common name) and source	Biomass	Grain yield	Overall performance
Dolicos lablab (lablab) INIFAP Sinaloa	3*	2	3
Lupinus sp. (lupine) ECOSUR-Chiapas	2	1	1
Lupinus sp. (lupine) GIRA Michoacán	2	1	2
Vicia sativa (Veza común) CIMMYT	2	2	2
Vicia sp (Veza de invierno) GIRA	2	?	1
Melilothus albus (white clover) CEDICAM Oaxaca	3	3	3
Phaseolus coccineus Regional	1	1	1

* 1, 2, 3 = low, moderate, and high, respectively.

Table 37. Agronomic characteristics of some legumes tested by farmers in LA Mixteca, Oaxaca, Mexico, 2000.

Species	Height	Cover	Flowering (days after sowing)	Bears fruit (days after sowing)	Dries (days after sowing)	kg/ha*
Local common bean	45.3	40	85	92	132	639
Bean *flor de mayo*	20	15	43	48	75	444
Bean *flor de junio*	21.3	18.3	48	65	90	373
Bean *DOR Chiapas*	25.4	22	57	55	85	797
Black bean *Zacatecas*	29.3	26.3	50	67	92	540
Brown lablab	54.5	14.67	110	115	160	744 **
Black lablab	42.9	14.2	68	75	120	
Vigna Cachito	32	—-	60	70	125	
Pigeon pea *Chiapas*	89.6	32.6	113	126	—-	
Pigeon pea ICRAF	98	25	160	175	—-	
Canavalia	67	65	80	100	—-	

* Data of Tomás Bautista of S. J. Nochixtlán, Oaxaca. ** Data of Sra. Joaquina Palacios from clay soils in Ayuquililla, Oaxaca.

away as Guanajuato and Zacatecas states, only the variety DOR slightly outyielded the local variety (Table 37), but the introduced varieties were earlier-maturing, offering farmers additional options for intercrops and rotations. In such cases, farmers will need to adjust sowing dates to take best advantage of rainfall patterns and, especially, to avoid the mid-season drought.

The pigeon pea grew slowly in the first year, mainly because precipitation was sparse during crop establishment. In the second year plants developed most fully and had good grain yields. This crop was planted in shallow soils (lajilla) and under conditions of scarce moisture. It was sowed in July 1999 in a contour ridge to help limit erosion and take advantage of the free space there. It survived the drought that year, as well as frequent grazing by goats, and sprouted again with the early rains the following year. The early-maturing varieties bore fruit in July and August; the ICRAF variety in November. The first year the early-maturing varieties were harvested in October and November, and the ICRAF genotype in January.

In the second year all pigeon pea genotypes were productive and vigorous despite a prolonged mid-season drought, while the lack of water wilted the maize and bean plants. Maize grain yield was zero, whereas the pigeon pea produced between 97 and 178 gm per linear meter (Table 38).

This shows that pigeon pea could be sown to make productive use of borders and ridges whose only prior purpose was erosion control. Data showed that only 10 linear meters of pigeon pea would produce 1-2 kg of grain, or farmers could also obtain fresh peas for use in soups or as side dishes.

In 2000 lablab also demonstrated its outstanding productive potential (Tables 35-39). Upon observing its performance in several plots, farmers concluded that it could be intercropped productively with maize.
In a sandy, porous field monocropped black lablab produced an estimated 0.268 t/ha of grain; a plot of brown lablab yielded around 1.0 t/ha (Tables 35, 37). Lablab outyielded common bean, producing nearly 0.4 t/ha in the case of brown lablab and 0.32 t/ha for black lablab (Tables 39, 40), when intercropped with maize and beans, and did not appear to affect the performance of either of the other crops.

Other potentially productive intercrops included maize-Vigna (*Vigna spp*; cowpea; a system practiced by a few farmers in the area) and maize-amaranth. The first was sown by farmer Luciano Soriano in Lunatitlán, with a cowpea yield of 0.378 t/ha, as opposed to 0.18 t/ha for common bean, without notably affecting maize production (around 1.1 t/ha). Maize-amaranth was tested by farmer Tomás Bautista of San Juan Nochixtlán. With the transplanting of his amaranth shoots delayed and no free land available, he decided to establish the amaranth among the 30-day-old maize seedlings, with good results for both crops. The same system was employed successfully by Juan Ramírez of Zapoquila.

Table 38. Characteristics of pigeon pea in shallow, low-fertility soils (lajilla), Lunatitlán, Oaxaca, Mexico, 2000.

Variety	Plantas / linear m	Plant height	Canopy diameter	Number ofgrains /10 linear m
Gandul Chiapas	1.91	76 cm	93 cm	970 gr
Gandul Oaxaca	2.13	70 cm	47.5 cm	1460 gr
Gandul ICRAF	2.54	140 cm	86 cm	1780 gr

Table 39. Performance of a maize-lablab-common bean intercrop (kg/ha), Nochixtlán, Oaxaca, Mexico, 2000.

	Maize	Beans	Brown lablab
Maize – bean	515	310	—
Maize – brown lablab – bean	570	330	389
Monocropped lablab	—	—	1,167

Table 40. Performance of a maize-lablab-common bean intercrop (kg/ha), Ayuquililla, Oaxaca, Mexico, 2000.

	Maize	Beans	Black lablab	Brown lablab
Maize – beans	1,615	50	0	0
Maize – lablab – beans	1,786	52	302	49

Human Resource Development

The poverty that Mixteca villages suffer — just as countless other communities in the Mexican states of Chiapas, Guerrero, Hidalgo, Puebla, Veracruz, and Oaxaca itself – is due not only to a lack of money or favorable production conditions, but stems from inhabitants' lack of confidence in themselves, their neighbors, their institutions, and their own knowledge; an outgrowth in part of a general social inertia. Project efforts were initially aimed at overcoming farmers' feelings of helplessness, in the face of difficulties such as a lack of water resources, and finally reached a point where farmer-experimenters were able to give clear presentations, supported by posters and a range of other support materials, regarding their experiences and results, in annual conferences involving peers, researchers from the project and elsewhere, and representatives of diverse institutions. The idea of peasant farmers giving a conference may cause amusement or surprise, or, as some Henri Hocdé might have said, "farmers' new role might frighten researchers".

Our aim was to encourage farmers to seek solutions to problems and queries, and I firmly believe we have achieved this. Today, after nearly three years of work to break the inertia of clientage, mistrust, and impotence, a group of more than 40 men and women farmers from the region believe they are experimenters. More than just a belief, they have proof in their fields of thought, conscious design, analysis, and evaluation – the hallmarks of productive research. Of course they employ their own criteria; but their native common sense, honed by years of battling for survival under extremely challenging conditions, often made up for any methodological shortcomings. We have awakened something in these farmers. Where before we had "cooperative peasants," now we have colleagues with whom we have sought and, in many cases, found answers. Through the attendant discussions, reflections, and effort, farmer experimentation to test agricultural technology has set in motion a process of self-motivation.

One of the groups from the project is now forming an association that will give it a legal presence and the power to marshall resources for pursuing other goals. Mixteca farmers may lack money, but they are not entirely bereft of resources – natural and human – and are now in a position to leverage these in benefit of their household well-being.

Bringing together these farmers to exchange data and experiences was perhaps a crowning achievement of the project. It is hard to imagine what it means for peasant farmers to stand before a group of 50 fellow farmers and 10 or more researchers and say "I did this…I saw that…I learned these things…I now know this… " So, shall we talk of human resource development?

Conclusions

Any conclusions to this work would have to cover the process and the technology. Regarding the latter, the most promising were green legume cover crops, above all grain legumes such as lablab and pigeon pea; oyster mushroom production; drip irrigation; greenhouse cropping; selection among local maize varieties, and triticale production. There is scant hope regarding the introduction of improved varieties of maize, given their poor performance thus far in the region's difficult environments.

Recognizing moisture as the number-one constraint, farmers have a strong interest in continuing to seek, test, and implement technologies to capture water (contour ridges, ditches, reservoirs, dams, and tapping of springs and marshes) and use it efficiently (drip irrigation, aspersion and micro-aspersion, and use of mulches, among other techniques). There is also the aim of combining soil and water conservation practices in systems that also provide farmers with additional income. As a complement to the above, there are plans to preserve and restore works from previous efforts aimed at soil and water conservation. Finally, all of this must be rolled into a promotional effort that overcomes the lack of interest in natural resource conservation and, rather, casts it as the platform for future, sustained development.

Regarding process, the project accomplished the self-motivated identification, adaptation, and testing of new technologies, making farmers the authors of their own agricultural development. There was also significant progress in the approach, which was based on farmer participation and intensive interaction among farmers and researchers to accomplish the above. Farmers clearly understand the key productivity constraints they face (except, perhaps, the effects of goat herding) and have at their disposal a menu of potential and some proven technical options. In addition, there are a greater number of progressive farmers and effective leaders in the communities, as well as a critical mass of farmer-experimenters with an enhanced capability of discussion and analysis. Participating farmers now comprehend the utility of experiments as a tool for testing and adapting new technologies to local conditions, as well as for disseminating and promoting relevant practices. They have also learned how to use their results in presentations, promoting organization, and generating and obtaining support for development projects.

Skills that could benefit from additional reinforcement and would help to consolidate a group of farmers that could serve as an engine of regional development include 1) planning and organizing experiments; 2) quantitative evaluation of experimental or promotional results; 3) communication and diffusion of results; 4) organization and seeking support for projects.

We regret that a change in donor priorities led to the cessation of funding for this project.

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