Why Improved Maize (*Zea mays*) Varieties are Utopias in the Highlands of Central Mexico

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Abstract: The objective of the work was to study of the establish the adoption of improved maize va ri et ies in the high lands of Cen tral Mex ico through the re sults of Spe cial Pro gram for Maize Pro duc tion in the high lands of the State of Mex ico (PEPMA). The work com prised two phases: the anal y sis of sta tis ti cal data and two sur veys, fol lowed by field work with open i n ter-views to farm ers par tic i pat ing in PEPMA in the vil lage of San Pedro la Concepción in the Val-ley of Toluca. The re sults show that vast ma jor ity of farm ers con tinue to sow their autoctonous land races, since hy brids or im proved va ri et ies are no real tech ni cal op tions given that they do not perform well in the productive con di tions of the high lands of Cen tral Mex ico.

Key words: Technology Adop tion. Im proved Va ri eties, Maize, Mex i can Highalands.

Resumen: *El obetivo de este trabajo consiste en el estudio de la adopción de variedades mejoradas de maíz en los Valles alto de México a través de los resultados del Programa Es pecial de Producción de Maíz del Estado de México (PEPMA). El trabajo comprende dos fases: el análisis estadístico de los datos del PEPMA y dos encuestas, seguidad por un trabajo de cam po con entrevistas abiertas a los agricultores participantes de la población de San Pedro la Concepción en el Valle de Toluca. Los resultados muestran que la gran mayoría de agricultores continúa sembrando sus semillas autóctonas, los híbridos o las variedades mejoradas no son opciones técnicas reales en tanto que ellas no se desmpeñan bien en las condiciones de la zona de estudio.*

Palabras clave: *Adopción de tecnología agrícola, variedades mejoradas, Maíz, Valles altos de México.*

Introduction

Maize (*Zea mays*) is the main sta ple crop in Mex ico and the ba sis of Mexican diets (Levy and Van Wijnbergen, 1992). There-fore, the im prove ment of maize has been a main stay ac tiv ity in the drive to modernise the agricultural sector in Mexico.

Genetic improvement of maize began in Mexico in 1938 when the "Office of Experimental Stations" was established in the Ministry of Agriculture and Promotion, having as its first director Mr. Edmundo Taboada. The emphasis then was the breeding of improved varieties of free pollination (IVFP). By 1940, the Mexican government signed an agreement for scientific cooperation with the Rockefeller Foundation, establishing the "Office of Special Studies" in the Ministry, initiating research into breeding hybrid maize varieties lead by Dr. Edwin Wellhausen.

After 60 years of maize breeding in Mexico, the achievements have been under discussion. According to some plant breeders, the imapact on the genetic improvement of maize was shown at the beginning of the 1970's in two aspects. Firstly, it was estimated that of the total surface of maize, between 7% (Celis, 1985:185) and 14% (Stakman, 1969:71) was sown to improved varieties.

Secondly, unquantifiable impacts were assumed from the use of improved varieties. This assumption stated that the genetic combination between improved and local varieties increased the overall yields of cultivated maize. This indirect "improvement" took place when pollen from improved plants fertilized the stigma of local plants (Ángeles, 1968).

On the other hand, the adoption of improved varieties has been low considering all the scientific and extension work done in Mexico, even under the most optimistic estimates[1], particularly in the highlands, where the local landraces of what is termed 'tropical highland maize' differ significantly from temperate or lowland tropical maize varieties where plant breeding has achieved greater success (Hardacre and Eagles 1980; Ellis *et al*., 1992).

Given this scenario, this work analyses the degree of adoption of agricultural technology, specifically of improved maize varieties in the highlands of Central Mexico through the analysis of results obtained

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[1] According to the UN Economic Commission for Latin America (CEPAL), the utilisation of improved maize varieties in Mexico by 1940 reached 3.4% of all farms (CEPAL, 1982). In 1988, it was estimated that 70% of farms used chemical fertilizers and that between 26 and 32% of all cultivated land was sown to improved varieties (Echeverría, 1988).

by PEPMA-*Programa Especial de Producción de Maíz* (Special program for Maize Production), a government program for the dissemination of modern agricultural technologies to increase yields of maize where a special emphasis was given to the adoption of improved varieties.

The study was undertaken in the highland valleys of the State of Mexico (altitudes over 1,800 m) under the consideration that PEPMA is a case of recent attempts to tranfer agricultural technology, in particular improved maize varieties, in an area, the State of Mexico, that has large agricultural research facilities since it has its own agricultural research institute ICAMEX-*Instituto de Investigación y Capacitación Agrícola, Pecuaria, Acuícola y Forestal del Estado de México* (Institute for Agricultural, Acuaculture and Forestry Research and Training of the State of Mexico), and is the venue of the International Research Centre for the Improvement of Maize and Wheat (CIMMYT), of the Research Centre for the Central Highlands of the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), and of several other institutions of agricultural higher education and research.

Also, the State of Mexico produces 20% of the total national maize production, which places it as the first largest maize producer among the 32 states that conform the Mexican republic (INEGI, 1996:340). In the State of Mexico maize is sown in more than 600,000 ha, representing 80% of crop land in the State (INEGI, 1996:340); such that the livelihoods of the vast majority of the 342,533 farming families of the State are weaved around this crop.

The work followed two phases: The first one is an analysis of statistical data, and the other is an ethnographic study.

The first phase analised three sources of information: The available data base of PEPMA for 1993 (DB-PEPMA-93); the results of a survey undertaken in 1993 on the whole of the PEPMA program carried out by a private independent consultancy firm (COSIA) and the first author of this paper (referred to as the COSIA-93 survey) with the objective of evaluating PEPMA, and which provides a profile of users of agricultural technical innovations including improved maize varieties; and an *ex-post* survey undertaken by the principal author in 1996 (refered to as the ex-post-96 survey).

The ethnographic study of the degree of adoption of modern agricultural technologies at a community level was done at the farming

village of San Pedro la Concepción, a community located at the centre of the Valley of Toluca (the city of Toluca is the capital of the State), with farmers participating in the PEPMA program since 1990. The Valley of Toluca produces around 30% of the maize in the State of Mexico.

Characterization of *campesino* farmers and their cropping practices in the highlands of the state of Mexico

In the State of Mexico, the total surface sown to maize ranges between 587,000 and 644,000 ha, of which 300,000 ha have access to irrigation and 200,000 ha are lo cated in ar eas of adquate rain fall. Of the to tal surface sown to maize, 496,000 ha are cultivated in the region known as the Highland Valleys of the State[2], of which 231,000 are either irrigated or receive good rainfall. PEPMA covered 28,750 ha in 1990; 58,911 ha in 1991; 74,193 ha in 1992, and 57,903 ha in 1993. This means that by 1992, the pro gram achieved its max i mal cov ered sur face sown to maize, which rep re sents slightly above 10% of the to tal sur face of the State sown to maize, and 32% of the best lands of the Highland Valleys.

In 1993, 8,083 farmers of the Highland Valleys who farmed 57,903 ha (mean farm size of 7.16 ha) participated in PEPMA. Data from 5,377 of these farmers, who farmed 43,738 ha were taken as the sampling frame work to con duct ob ser va tions. These fig ures rep re sent 65% of farmers and 75% of the land covered by PEPMA in the Highland Val leys. This frame work was not se lected by sta tis ti cal pro ce dures, but was formed by eliminating data from farm ers from whom no com plete files could be found, but taking care that the farm ers not incuded in the framework were not specifically biased against.

The COSIA-93 survey was carried out to a sample of 774 farmers[3] participating in PEPMA in 1993, and a further questionnaire was applied by the principal author to other 104 farmers in 1996 (the

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[2] The highland region is characterised by altitudes above 1,800 m, and comprises the agricultural districts of Atlacomulco, Toluca, Jilotepec, Zumpango, Texcoco and a part of Valle de Bravo.

[3] The survey was conducted with 202 frmers of the District of Toluca, 9 in Zumpango, 63 in Texcoco, 378 in Atlacomulco, 30 in Valle de Bravo and 82 in Jilotepec (COSIA, 1994).

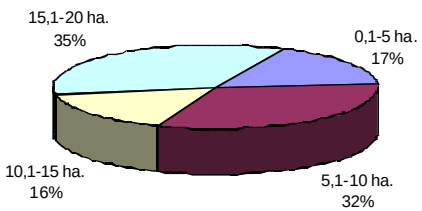
ex-post-96 survey). The second and third surveys are taken in this paper as complementary to the first source of information. This is supported by the close relationship of information in the three surveys.

Of the total farmers participating in PEPMA in 1993, 24.7% had also participated in PEPMA in 1990, 17.6% in 1991, 29.4% in 1992 and 28% had not participated. Therefore, in 1993, 28% of farmers did not have any previous experience of participating in PEPMA, whilst only 24.7% of farmers participated cotinuously during four years.

In 1993, 60% of participants were part time farmers, since generally these farmers migrate seasonally in search of paid jobs in the cities (Woodgate, 1994). The *ex-post* survey in 1996 showed that 93.3% of farmers were men, while only 6.7% were women.

In 1993, the distribution of farm size in ranges of 5.0 ha was: 17% of farmers held between 0.1 and 5.0 ha, 32% between 5.1 and 10.0 ha, 16% between 10.1 and 15.0 ha and 35% between 15.1 and 20.0 ha (Figure 1). The mean farm size was 7.0 ha. Before 1993, 44% of had farms of less than 2.0 ha, while by 1993 less than 17% of farmers had less than 2.0 ha. This means that in relation to the previous years, PEPMA in 1993 selected "elite" farmers wirh larger farms.

Figure 1. Percentage of farmers according to the surface range of their Units of production



Source: files of PEPMA -94

The *ex-post* survey of 1996 showed that the percentage distribution of farm size was different, and that 8.8% of participating farmers held farms larger than 20.0 ha, including some that cropped 120.0 ha. This

situation was not evident from previous surveys due to legal restrictions imposed by the agrarian law (modified in 1992); and therefore the fear of some farmers of declaring ownership of larger farms than the legal maximum size allowed by the old Agrarian Law (100.0 ha).

Before analysing the use of improved maize varieties, the use of other agricultural innovations by the surveyed farmers is reviewed. Farmers utilised agricultural machinery for tilling and cultivating the land in 89% of the total surface, while animal drawn implements were used in 11% of the land. Sowing with tractor was practiced in 87.4% of the land, whilst the rest was sown with animal traction. Cultivations were undertaken with animal traction in 9% of the land, 88% utilised tractor, and 3% did them by hand.

The survey of COSIA-93, and the *ex-post* survey in 1996, confirm this high percentage of mechanization of participating farmers. Farmers of the Highland Valleys have highly adopted agricultural machinery in their practices, although a high number of them rents them in.

At the time of harvesting, the use of combine harvesters is not common, since only 17% of the land is harvested with machinery[4].

How can it be explained that 83% of the land is harvested by hand when it needs 20 man/days per hectare? Although this question does not belong to the topic developed in this paper, it may be said that according to observations, by the end of the year work in the cities tends to decrease and the family members take advantage to return home and participate in harvesting.

Fertilisation is a practice that was introduced since the 1940's, and since then the increasing use of synthetic fertilisers has caused the progressive loss of the natural fertility of soils. The result is a vicious circle of increased amounts of fertilisers used with increased loss of natural fertility. In 1993, the surveyed farmers applied 263 fertiliser formulaes,

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[4] In 1996, 95.2% of farmers stated to have harvested maize by hand. The increase of 12 percentage points in manual harvesting compared with 1993 may be explained due to the effect of the economic crisis of 1994/1995, which would have impeded the rent of harvesting machinery after the 1994 harvest.

of which, 16 were the most commonly used (Table 1). Farmers increased the amount of fertilisers used up to 25% above the rates recommended by extension agents[5].

Table 1. Fertiliser formulaes most commonly used by farmers

Number of farmers	First fertilisation	Second fertilisation
206	36-92-30	115-00-00
120	50-69-30	115-00-00
102	80-90-30	90-00-00
161	70-60-30	70-00-00
158	70-70-30	70-00-00
153	70-80-30	70-00-00
254	73-60-30	87-00-00
233	70-70-30	70-00-00
201	70-60-30	70-00-00
114	36-92-30	90-00-00
204	40-60-30	80-00-00
128	40-60-30	80-00-00
135	46-92-30	90-00-00
115	50-60-30	90-00-00
335	60-60-30	70-00-00

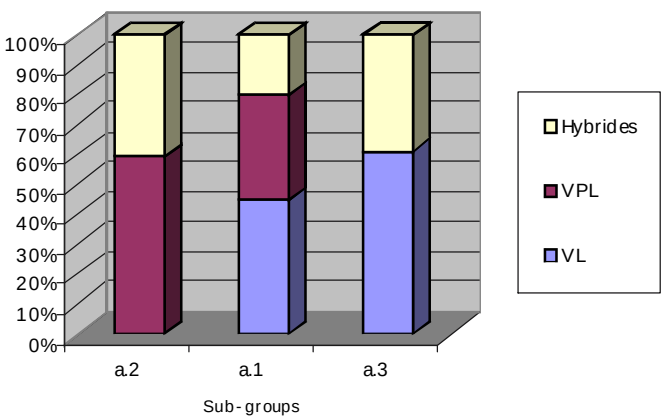
The formulae read: kg Nitrogen, kg Phosphate, and kg Potassium
Souce: Files of ICAMEX (1994) and COSIA (1994).

According to agricultural researchers, farmers have over applied the recommended rates of nitrogen fertilizers since this element was directly linked, over many decades, to the increase in the productivity of plants (Álvarez, 1991). The *ex-post* survey of 1996 showed that 94.2% of farmers usually apply synthetic fertilizers at least once in the cropping cycle, and 67.3% give a second application.

[5] The recommended rates for the Highland Valleys is 120-60-30 under irrigation or residual moisture, and 90-50-30 for rainfed conditions (ICAMEX, 1994).

Researchers in the productivity of agricutural systems consider that it is not enough to sow good seeds to obtain the benefits of a technological package. They recommend a plant density between 60,000 and 70,000 plants per hectare as an adequate density to obtain high yields (Turrent *et al.*, 1992). The plant densities achieved by the majority of farmers in the study (78.6%) were between 50,000 and 70,000 plants/ha, which are in line with the recommendations (Figure 2).

Figure 2: Percentages of sowuing hibrid, IVFP and LV by farmer´subgrup



Source: files of PEPMA-93

It can be said that the use of technicalinnovations for the maize crop is essentially in accordance with the recomendations of scientists. However, technological innovations as the use of pesticides, herbicides, agricultural machinery and even fertilisers, do not come from the research stations in the area of study; but they flow through networks that start with transnational companies that generate many of these inputs, and arrive in Mexico and the study region through the relationships of those firms that produce them with the marketing and commercialisationactivities of local companies, where the farmers are

the last point of this network, which links them to it and transforms them in consumers of these inputs. The recommendations for use of these agrochemicals appear on the labels, so that farmers usually have little or no direct contact with Mexican agricultural researchers or their findings.

Adoption of improved maize varieties in the highland valleys

In the 1980's, Mexican plant breeders considered that there was a set of commercial improved maize varieties released by the National Institute of Forestry, Agricultural and Livestock Research (*Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias* - INIFAP) that were adapted to the agricultural conditions of the highlands of central Mexico. The following hybrids were available for the irrigated areas: H-127, H-129, H-131, H-133, H-135; and for areas of rainfed agriculture the available hybrids were H-28, H-30, H-32; as well as the following improved varieties of free pollination (IVFP) suited for rainfed conditions: VS-22, V-23, and V-29 (Arellano-Vazquez, unpublished).

In the Highland Valleys of the State of Mexico, the agricultural research and training institute of the state government ICAMEX had released the following improved varieties of free pollination (which originated in local landraces): Acambay, Santiago Yeche, Almoloya de Juárez, Ixtlahuaca, Amarillo Zanahoria ('Carrot Yellow'); as well as two synthetic IVFP: V-11, and V-105.

Table 2. Yields of improved and hybrid varieties most utilised in the Highland Valleys of the State of Mexico

Varieties released by INIFAP		Varieties released by ICAMEX	
Variety	ton/ha	Variety	ton/ha
V-22*	5,8	Acambay ***	7,3
V-23*	6,7	Almoloya ***	7,1
H-28**	6,4	Amarillo zanahoria ***	7,2
H-30[1] **	7,1	Ixtlahuaca ***	7,7
H-32[1] **	7,0	V-11 *	7,8
H-34 **	7,3	V-105 *	7,5

* Synthetic free pollinating variety.
** Hybrid.
*** Improved free pollinating variety.
[1] Hybrid form by an agreement between INIFAP and ICAMEX.
Source: GEM-FIRCO (1990:2).

During the time of PEPMA, from all of these varieties, farmers had access mainly to the four hybrids, four synthetic varieties and four improved free pollination varieties shown in Table 2.

The use of improved varieties by farmers did not meet the expectations of scientists. Of the 5,377 farmers included in the first survey, there were three distinct groups: those who sowed hybrids (a) or improved free pollination varieties (b) in at least a part of their farm, and those who sowed only local varieties (c).

a) The group who sowed a part of their farms with hybrids was formed by 223 farmers who cropped 3,312.0 ha with hybrid varieties, which represented 5% of the total land surveyed (Table 3 and Figure 3).

Table 3. Use of improved varieties by surveyed farmers participating in PEPMA 1993[1]

Group	Type of varieties	Surface (ha)	Mean Farm Size (ha/farm)	Numbre of Farmers
a.1	Hybrids	1 770.5	16.0	111
a.2	Hybrids+IVFP	400.5	14.3	28
a.3	Hybrids+IVFP+LV	539.0	14.8	38
a.4	Hybrids+LV	602.0	13.0	46
b.1-b.4	IVFP+LV	3 182.7	12.6	249
b.5	IVFP	2 167.0	13.0	167
c.	Local varieties	35 076.3	7.4	4,738
	Total	43 738.0	---	5,377
	PEPMA-Highland Valleys	57 903.0	7.0	8 216

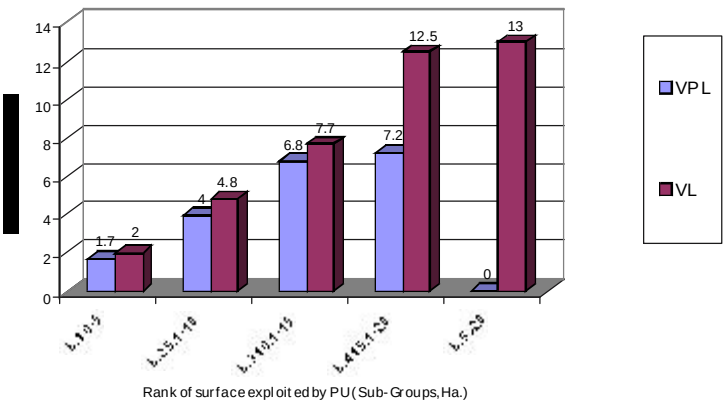
[1] 65% of farmers and 75% of the land from ICAMEX, 1993.
Source: COSIA (1994).

Farmers in this group had farms between 13.0 and 16.0 ha, which can be compared against those farmers who cropped exclusively local varieties (LV) who had a mean farm size of 7.4 ha. This first group was formed by four sub groups. Those who exclusively sowed hybrids (a.1), those who cropped hybrids and improved varieties of free pollination (IVFP) (a.2), those who cropped hybrids with IVPF and local (unimproved) varieties (LV) (a.3), and those who grew hybrids and LV (a.4).

The (a.1) group was formed by 111 farmers who exclusively grew hybrid varieties, representing just 4% of the total land within the PEPMA. Another 112 farmers (groups a.2, a.3 and a.4) sowed at least part of their farms to hybrids, and the rest with another maize variety.

Of these 112 farmers, the 28 farmers of the a.2 group sowed 60% of their land to IVFP; the 38 farmers of the a.3 group sowed only 20% of their land to hybrids, 35% to IVFP and 45% to LV; and the 46 farmers of the a.4 group sowed 65% of their land to LV. (Figure 3).

Figure 3. Seed types used in the Units of Production (UP) per range of mean surface of the group that sows IVFP and LV



Source: files of PEPMA -93

Of those farmers who grew hybrids with some other varieties, the most outstanding aspect is that they grew local varieties in proportions that are above 50% of their farms. The the subgroup a.2 who grew hybrids with IVFP sowed 82% of their farms to these latter varieties, the a.3 sub group, who grewsthe three types of varieties (hybrids, IVFP and LV) sowed 44.5 % to local varieties (LV), those in and the sub group a.4 kept 60 % of their land to grow their own varieties.

The logic of these behaviour is that the majority of farmers in the Highland Valleys have no confidence in the yields they may obtain from growing hybrid varieties. This will be discussed in detail when the findings in the village of San Pedro la Concepción are discussed.

The b) group consisted of 416 farmers who did not grow hybrid varieties and used only IVFP or local varieties. The group may be arranged in five sub groups given the range of crop ped land and type of varieties sown (Figure 3).

Subgroup b.1). formed by 23 farmers (5.6%) with farms between 0.1 and 5.0 ha, sow ing 47% of their farms to IVFP and 53% to LV; subgroup b.2) was formed by 44 farmers (10.6%) who had farms between 5.1 and 10.0 ha, and sowed 48% of their land to IVFP and 52% to LV; subgroup b.3) also of 22 farmers (5.3%) cropped between 10.1 and 15.0 ha, and sowed 47% of their farms to IVFP and 53% to LV; subgroup b.4) formed by 48 farmers (11.5%) had between 15.1 and 20.0 ha, grew IVFP in 36.6% of their land; and subgroup b.5), who exclusively grew IVFP was formed by 67% of the 416 farmers (279), had farms with a mean size of 13.0 ha.

As can be seen, 33% of these farmers also decided not to sow more than 50% of their land to IVFP, trusting more the performance of their local varieties.

Group c), the vast ma jor ity of farm ers (4,737) who grew ex clu sively indigenous local varieties in farms with a mean size of 7.4 ha, representing a total of 35,076 hectares.

It can be concluded at this stage that im proved maize va ri et ies were not commonly used in the Highland Valleys of the State of Mexico, even within the PEPMA program. The improved hybrid varieties are only used exclusively by a very small sector of the surveyed farmers (111) representing only 2.1% of total farmers; who have the larger mean farm size from all the farmers surveyed (16.0 ha/ farm); compared with the vast majority (88%) of farmers who retained their habit of sowing, and conserving, their antique, indigenous local varieties[6].

These farm ers had a mean farm size of 7.4 ha, which is less than half the farm size of farm ers grow ing only hy brids, and four times the mean farm size of the overall maize farmers in the State of Mexico.

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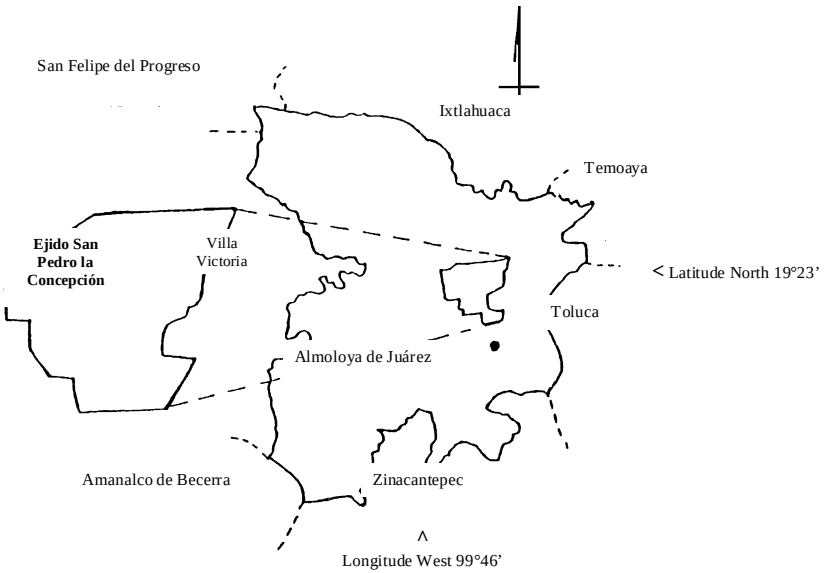
[6] The *ex-post* survey in 1996 showed that 13.5% of farmers grew improved varieties (hybrid and IVFP), while the remaining 86.5% continued growing their indigenous varieties.

Figure 4. The village of San Pedro la Concepción, State of Mexico



Source: Trigos, 1992:42

On an overall state context, the results obtained from the above analysis are confirmed by the fact that the use of seed from improved varieties is very limited. According to the Mexican national system for the certification and inspection of seeds (*Sistema nacional de certificación e inspección de semillas*), the sales of seed from improved varieties were, in the State of Mexico, of 221.7 ton in 1991, 252.8 ton in 1992 and 258.7 ton in 1993. Considering the recommended sowing rates of 25 kg seed/ha, these figures represent 8,868 ha, 10,348 ha and 10,348 ha sown in 1991, 1992 and 1993 to improved varieties. Therefore, utilisation of improved maize varieties in the state was 1.38% in 1991, 1.58% in 1992 and 1.76% in 1993, of the total land sown to maize.

The 5,377 farmers participating in the PEPMA program considered in this study sowed in 1993 3,312.0 ha of hybrid varieties and just over 4,000 ha of IVFP, representing 16.7% of the surveyed land being sown to improved varieties.

If this figure in the use of improved varieties in the surveyed farms is applied to the whole of the 57,903 ha participating in PEPMA in the

Highland Valleys of the State of Mexico, it would represent 8,106.4 ha sown to improved varieties, which would mean that farmers participating in PEPMA would have used 78.3% of the state total of seed of improved maize varieties.

In any case, from the available figures it may be stated that the surface sown to improved varieties in the area of study utilised between 59.2% and 78.3% of the State total of improved seed stock (by dividing the surface of the study sown to improved seeds into the total surface of the State of Mexico sown to improved seeds). This means that: 1) the surface of the State of Mexico sown to maize substracting the study area was 543,692 ha (587,430 ha of the State's land sown to maize minus 43,738 ha from PEPMA); 2) the land sown to improved varieties substracting the study area was 3,036.4 ha (10,348.4 ha of the State's land sown to improved varieties minus 7,312.0 ha of the study area); 3) the land sown to improved varieties in the study area was 7,312.0 ha, which represented 17% and 1.24% of the land sown to maize with improved varieties for PEPMA and the State of Mexico respectively, and; 4) the rate of utilisation of seed of improved varieties outside the area of study was only 0.06%.

It may be concluded from the available data, only 24.7% of the participating farmers in PEPMA in 1993 were the same as in 1990. Sixty percent of participants were part time farmers since they have to migrate out of their villages to find paid jobs in the cities. Participating farmers had mean farm size of 7.0 ha per farmer, which means that the majority of farmers holding mean surfaces of 2.0 ha/farmer did not benefit from the government subsidy in PEPMA.

Farmers were usually utilising farm machinery, synthetic fertilisers and other innovations as the plant density recommended by research institutes. However, the majority of farmers refused to utilise the improved varieties recommended by PEPMA extension agents.

The following section shows the information from the field work undertaken in a village in the Valley of Toluca with the objective of finding answers to the rejection of farmers towards improved varieties.

The use of agricultural technology and improved maize varieties in *San Pedro la Concepción*

Hereinafter, the rate of adoption of improved maize varieties in the village of San Pedro la Concepción is discussed.

The vil lage of San Pedro la Concepción is lo cated in the municipaity of Almoloya de Juárez which belongs to the agricultural district of Toluca , and has a population of 1,181 inhabitants (IGECEM, 1995) (Figure 4).

Ninety per cent of the houses in the vil lage have elec tric ity and piped water. on electricidad y agua potable, and 100% of the families have a radio and 70% television. The village is accesible by road all year round.

Food is based primarily in the consumption of maize, such that the majority of farmers allocate their production to self-consumption and to the feeding of their livestock (devoted also mainly to self consumption).

Forty per cent of farm ers mi grate seasonaly to work in the cit ies, and at least a mem ber of the fam ily works per ma nently out side the vil lage.

In 1936, whithin the framework of the Mexican Agrarian Reform, 144 farmers obtained the rights of use of 786.20 ha of which 109 ha have access to partial irrigation and the rest are rainfed.

In 1936, farmers held 4.5 ha of rainfed land and 0.75 ha of irrigated land per farmer. At present, due to population pressure, land holdings per farmer have decreased drastically, such that 7.8% of farmers have les than 1.0 ha, 50.7% have 1.0 ha, 7.5% have between 1.25 y 1.5 ha, and only 20% hold more than 2.0 ha. In San Pedro la Concepción, as in vast areas of the Highland Valleys, one of the most important constraints for agriculture is the diminishing size of production units. This de crease in the size of land hold ings per farmer leads to a loss of in ter est in the ma jor ity of the in hab it ants of San Pedro la Concepción to get involved in ag ri cul ture, seek ing crop ping sys tems that rely less in la bour, inputs and capital (Trigos, 1996: personal communication).

In 1990, the management of PEPMA hired an agronomist as an extension agent to integrate a dessemination unit in San Pedro la Concepción. In a few weeks, he was able to unite a group of 44 farmers interested in participating in PEPMA with their 146.5 ha (Table 4). This unit had less than half the surface set by PEPMA administrators (350 ha) to establish an extension unit.

In 1990, these farmers sowed 19 ha with the hybrids H-28 y H-30 (13% of their land), 12.75 ha with the IVFP *Almoloya de Juarez*, and *Amarillo zanahoria* (“Carrot Yellow”) (9% of their land) and 114.75

ha (78% of their land) with local varieties. Twenty farmers sowed Local Varieties (LV) exclusively, 18 sowed hybrids and LV, four sowed IVFP and LV, one sowed only IVFP, and one sowed hy brids and IVFP. No one sowed ex clu sively hy brids. Of all farm ers, none sowed hy brids or IVFP in a larger pro por tion than LV, which is sim i lar to the ob served values in PEPMA's area of study in the Highland Valleys mentioned earlier.

Table 4. PEPMA in San Pedro la Concepción in 1990

Varieties	Total land (ha)	Mean land/ farmer	Total Yield (t)	Maximum Yield (t/ha)	Minimum Yield (t/ha)	Mean Yield (t/ha)
H-28	4.00	1.00	21.0	5.5	5.0	5.25
H-30	15.00	1.07	79.1	5.9	4.6	5.32
Almoloya de Juárez	3.00	1.00	16.1	5.6	5.0	5.37
Ixtlahuaca	4.75	0.95	23.9	5.6	4.1	5.06
Amarillo Zanahoria	5.00	2.50	22.2	4.5	4.4	4.45
Local Varieties	114.75	2.30	482.4	5.9	4.0	4.16
Total or Means	146.00	1.47	644.7	5.5	4.5	4.90

Sources: Files of ICAMEX (1993) and Trigos (1992:52-58)

In San Pedro la Concepción, the impact of PEPMA was weak. Only 30% of farmers wanted to participate in this program with 19% of the total agricultural land of the village, so that 100 out of 144 farmers chose to say out of PEPMA.

According with the principal author's conversations with non participant farmers, some of them did not participate out of not hav ing the documents to prove legal ownership of their land. This is because after the 1936 land distribution by the government, the following generations of *campesino* farmers continued bequeathing, without legal docu ments, ever smaller plots of land to their heirs; which ex plains the excesive partition and small size of farms in San Pedro la Concepción, as is the general experience in the Highland Valleys.

For other farmers, the small size of their farms does not justify committing their participation in any program.. For this type of farmers, maize cultivation represents a weekend activity. It is common for men to mi grate out of the com mu nity in week days to work in the cities, and return during the weekend to visit the family and take decissions, among those, the management of the farm.

For other farmers, the farms are like "nursing homes" where the elderly remain in the countryside while the youngsters have emigrated to the cities. That is the case for some of the farmers whose generation benefited from the land reform of 1936, as well as some other farmers from the following generations who are now old and have no interest, nor money, to modify the management of their maize crop.

These social changes in the countryside have impaired the adoption of technical innovations where the prospects of obtaining profits are not well established.

Also, according to interviewed farmers who did not participate in PEPMA, the performance of improved varieties is haphazard in relation to the climatic conditions in San Pedro la Concepción. The answer from these farmers is overwhelming: *none utilises improved varieties or high concentration fertilisers.*

In 1990, the most outstanding facts of the extension agent's activity in San Pedro la Concepción was the introduction of improved variety in 21% of the land of the participating farmers (and only 4% of the village), the utilisation of fertilisers of high concentration and foliar fertilisation, and the payback of bank credits (Trigos, 1992:32). The agronomist himself recognises the importance of having had good climatic conditions in that year in the yields obtained by farmers, which is also acknowledge in PEPMA's general results.

Farmer participation in PEPMA for 1991 and 1992 was very irregular, with only six farmers participating in 1991, and four in 1992. By 1993, only Mr. Atanacio Palma Gonzaga, Mr. Abundio Munguía Flores and Mr. Jesús Carmona Martínez continued to participate. According to interviews to the extension agent and farmers, the main reason why farmers abandoned participation in PEPMA was the large credit debts accumulated in 1991 and 1992.

From interviews held in Autumn 1994 to 13 farmers who had participated in PEPMA, in regards to their technical evolution, farmers thought that cropping practices had not changed through PEPMA, since they already applied fertilisers, pesticides and herbicides with products bought in Toluca. According to them, the extension agents of PEPMA did not provide any new knowledge on the cultivation of maize.

In relation to fertilisers, farmers apply 136 kg of Nitrogen, 90 kg of phosphate, and 30 kg of potash (136-90-30), formula which is above

what extension agents recomend (Table 1). Farmers apply these amounts since they consider it the only way of obtaining good yields.

In relation to improved varieties, 10 of the 13 interviewed farmers had sown hybrids in the past, although none had done so since 1993. All considered hybrid seed to be expensive inputs in relation to the profits obtained.

On the other hand, they say that although the grain of hybrids is larger, they are "lighter" (less dense). Given the fact that maize is sold by weight and not volume, they would rather cultivate local varieties or IVFP since they yield heavier grains although they might be small. At harvest time, the differences in yield between hybrids and free pollination varieties is minimal or even favourable for the free pollination varieties.

Also farmers do not like that improved seeds have a higher price than their own seed. In 1990, the price of improved seed was 7 pesos, whilst the price of maize was between 5 and 6 pesos. Similarly, in 1994, the price of grain was 1.5 pesos while the price of improved seed was up to 9 pesos (Trigos, 1996: personal communication).

Farmer statement clash with the extension agents perception. For example, according to the extension agent, farmers do not take advantage of the improved varieties because they are not willing to become disciplined and adopt the technological packages recommended by the extension agronomists of PEPMA.

Thus, the last negotiation on the use of cientifically improved maize was held within the relationship between extension agents and farmers in terms of the benefits of sowing improved varieties of maize. Throughout PEPMA, farmers agreed to cultivate the hybrids recommended by the extension agent only in less than half of their land, which corroborates the figures obtained in PEPMA 1993, where less than 50% of the lands were sown to hybrid or improved seed.

By 1994, none of the farmers in San Pedro la Concepción was willing to follow the extension agents recommendations to sow hybrids, although the 13 interviewed farmers would be disposed to try new hybrid seeds as long as they do not show the limitations perceived in currently available hybrid seeds (mainly that yields are prone to be severely affected by less than favourable climatic conditions, and the high price of seed).

Conclusions

Chemical (fertilisers and pesticides) and mechanical innovations have had an impact on the organization of labour and have notably influenced the productive practices of farmers, but in terms of improved maize varieties, farmers continue to utilise their local varieties. Despite scientific efforts to provide new plants of maize, the practice of sowing autoctonous seed is performed almost unchanged since over six thousand years ago.

Independent of the most optimistic figures in regards to the use of improved varieties, including hybrids, the reality is far removed from the one envisaged by the team of the Office for Special Studies (*Oficina de Estudios Especiales*) of the Rockefeller Foundation when they proposed to cover Mexican land with hybrid maize varieties.

Also, the hopes of Edmundo Taboada and his team at the Office of Experimental Stations (*Oficina de Campos Experimentales*) of utilising stable free pollination varieties did not happen either. The followers of these plant breeding research have not been able to build an extensive and stable stock of improved free pollinating maize varieties.

After 60 years of scientific research and extension of manipulated maize varieties, farmers keep their ancestral alliance to autoctonous seeds, since hybrids or improved varieties are utopias.

In recent times, farmers have accepted occasionally to sow hybrids since extension agents have brought hybrid seeds as part of credit schemes, or have been technically convinced by the extensionists, who have promised to subsidise the price of seeds, have convinced them by means of technical arguments, or have coerced them in the fashion of pushy salespeople.

The rejection to sow hybrid and improved varieties means the implicit rejection to the extra care that these plants require from the farmers who would need to over protect the maize plants, and/or run the risk of lossing all of their investment if unfavourable weather conditions ensue, or to harvest lighter grains in relation to local varieties. In the case of hybrids, farmers also do not accept the need to buy hybrid seed every year.

If scientists have underestimated the extra labour and care requirements that cultivating hybrids or improved varieties mean to farmers,

there is a majority of farmers there to limit the existence of improved varieties by the continued sowing of their local varieties which, although having small but heavy grains, do not require anything else than to sow the grains harvested in the preceding agricultural cycle, as they have been doing for generations. In short, for the vast majority of farmers in the highland Valleys, currently available hybrid and improved varieties are no real technical options to stimulate production.

The extension project based on the idea of delivering the developed technical aspects of maize cultivation from the experimental stations to the farmer's fields was much more complicated than the optimistic proposals of the extension agents. The story of PEPMA shows a number of problems that fall within the explanation that a good technology cannot be applied by farmers due to political or social reasons. It also lies in the explanation of an ill conceived technology.

According to the first explanation, the lack of real efforts from federal and state governments, the conflicts between the teams of extension agents, and the bank credits which arrived late, contributed to immobilize PEPMA, and turned the proposal to improve the productivity of farms into an unachievable project. It may be said that, even not considering political mistakes, farmers are not able to adopt new technologies produced by scientists since the improved varieties do not perform well in the productive conditions faced by the majority of farmers.

The big mistake started in the 1940's, when plant geneticists decided to follow plant breeding schemes that farmers did not want.

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