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Genetic Diversity and Maize Seed Management in a Traditional Mexican Community: Implications for *In Situ* Conservation of Maize

Dominique Louette and Melinda Smale

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Contents

Abstract

Results from a study of maize varieties and seed sources in a traditional community in Mexico raise questions about the relevance of models for *in situ* conservation of crop genetic resources that are based on geographical isolation of the community, as well as the relationship between genetic erosion and the introduction of varieties. The morphophenological diversity of local materials is shown to be enhanced by introductions of both improved cultivars and landraces from farmers in other communities. Evidence on seed sources and selection practices also reveals that the geographical point of reference for defining a "local" landrace is larger than the community itself. Farmers often obtain seed for their landraces from other farmers in and outside the community, rather than select seed exclusively from their own harvests. A farmer will classify seed obtained from another community as that of a local landrace if it resembles one of his own, according to the phenotypic characteristics that he uses to distinguish varieties. A more appropriate model for conserving maize diversity in this community would be to permit a certain level of introductions while assuring that the extent of cultivation of local varieties is sufficient to maintain a desirable level of polymorphism. The design of such an *in situ* system would clearly be much more complex than the simple model based on geographical isolation would suggest.

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Genetic Diversity and Maize Seed Management in a Traditional Mexican Community: Implications for *In Situ* Conservation of Maize

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Introduction

A major preoccupation of those concerned today with the conservation of plant genetic resources is that in many regions of the world, farmers have economic incentives to replace the varieties that evolve within their own agrosystem with improved, introduced varieties. To forestall the disappearance of locally evolved varieties in farmers' fields, some have proposed *in situ* conservation as a complementary strategy to *ex situ* conservation of genetic resources in gene banks. As originally defined, *in situ* conservation means preserving, in their original agrosystem, varieties cultivated by farmers using their own selection methods and criteria (Bommer 1991, FAO 1989, Keystone Center 1991).

One model of *in situ* conservation, described by Iltis (1974), is that of a reserve in which neither changes in cultural practices nor the introduction of foreign genetic material are permitted. In essence, *in situ* conditions would reproduce the conditions found in *ex situ* conservation, by fixing genetic structures and growing environment. The reserve model has been criticized widely on the grounds that it is not feasible for socioeconomic reasons. The model has also raised numerous questions about how policies aimed at fostering economic development relate to those designed to conserve plant genetic resources and whether conservation can coexist with the integration of communities into commercial markets (Cohen et al. 1991, Cooper et al. 1992, Montecinos and Altieri 1991). More specifically, should the objective of *in situ* conservation be to fix the genetic diversity of the landraces cultivated in traditional farming systems? Is this view of *in situ* conservation consistent with the way traditional farming systems function? Does it respect the mechanisms that explain the diversity found in farmers' fields for an open-pollinated, cultivated plant such as maize ?

Answering these questions requires two fundamental pieces of information which have been largely missing from the debate over conservation strategies. The first is a clear definition of conservation objectives in terms that are meaningful for scientists, policy makers, and those who inform policy makers. The second is specific knowledge about the origin and dynamics of the diversity that can be observed on traditional farms. To be able to define precisely the objectives, limits, and means for implementing *in situ* conservation, it is necessary to obtain a better understanding of the structure of polymorphism within farmers' varieties, how it evolves with farmers' practices, and the methods and mechanisms for managing this source of diversity (FAO 1989, Brush 1992). Without this information, neither a constructive debate nor an adequate methodology for *in situ* conservation can be established.

The larger study from which the arguments and data presented here are drawn (Louette 1994) examines the structure of genetic diversity in maize and analyzes the effect of farmers' seed management strategies on this structure in Cuzalapa, an indigenous community of western Mexico. Two specific questions are examined in this paper. The first is to what extent the genetic diversity that can be observed in the maize varieties of Cuzalapa results from the management of materials of strictly local origin. The second question is to what extent the introduction of foreign material is associated with a loss of genetic diversity. Data on sources of seed illustrate the important role played by seed acquired from other farmers in and outside the region relative to seed that local farmers obtain from their own harvests. Analyses of phenotypic and phenological characteristics, combined with data on origin of seeds, demonstrate the effect of introduced varieties on the diversity of maize cultivated in the Cuzalapa community.

The next section of this paper summarizes essential features of the farming system in Cuzalapa. Subsequent sections include a description of the methods used in the study, results of the analysis of data on genetic diversity and seed flows, a discussion of results, and the implications of our findings for the questions posed above.

The Valley of Cuzalapa and the Sierra de Manantlán Biosphere Reserve (SMBR)

The indigenous community of Cuzalapa is located in a valley in the southern section of the buffer zone of the Sierra de Manantlán Biosphere Reserve (SMBR), in the municipality of Cuautitlán on the Pacific Coast of Mexico (Figure 1). The Biosphere Reserve's interest in conserving *in situ* the genetic resources of the genus *Zea* (Jardel 1992) is explained by its location on the Pacific Coast of Mexico, which may be one of the zones where maize originated (Benz and Iltis 1992). In the reserve and nearby, various species of *Teosinte* (a wild relative of maize) are found,[1] growing alongside primitive races of maize such as Tabloncillo and Reventador (Wellhausen 1951, Benz 1988 and forthcoming, Benz et al. 1990).

The regional importance of Cuzalapa has declined since the beginning of the colonial period in the 16th century, when it became the principal community of the Provincia de Amula de Occidente. The valley of Cuzalapa has approximately the same number of inhabitants today (1,500) as it did in 1540 (Laitner and Benz 1994). Although it is one of the largest communities of the Biosphere Reserve, Cuzalapa is also located in one of the most marginalized municipalities of the region, based on quality of housing and level of education. The population is distributed among the main village of Cuzalapa and 23 other localities. At the time of this study (1989-91),

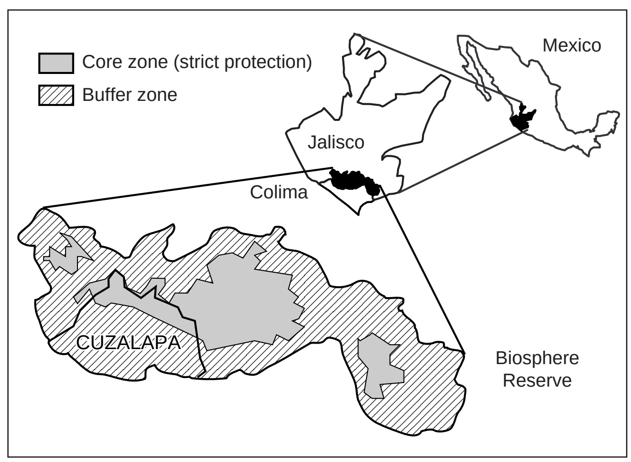

Figure 1. Location and zoning of the Sierra de Manantlán Biosphere Reserve and the Cuzalapa indigenous community limits within the reserve.

[1] *Zea mays* spp. *parviglumis* Iltis, Doebley; *Zea diploperennis* Iltis, Doebley, Guzmán; and *Zea perennis* (Hitchc.) Reeves, Mangelsd.

these localities were all relatively isolated from major roads and urban areas.

Because of its largely indigenous population, the valley of Cuzalapa was officially recognized as a *comunidad indígena* (indigenous community) under the Agrarian Reform of 1950. Theoretically, land in the valley is held in common and political structures are based on traditional institutions such as the *consejo de ancianos* (council of elders). The community nevertheless functions like an *ejido*[2] in the sense that land is partitioned among the *comuneros* and its use is governed by an elected assembly. A great proportion of the inhabitants are in fact *mestizos* (of combined European and indigenous ancestry).

The Cuzalapa watershed covers nearly 24,000 ha (most of which lies within the boundary of the Biosphere Reserve) of mountainous land of extremely irregular topography, ranging from an elevation of 550 m to 2,660 m. The agricultural zone is located at an elevation of 600 m and has a hot subhumid climate, with a mean annual temperature of 22°C and mean annual precipitation of 1,500 mm, concentrated from June to October (Martínez et al. 1991). Fields used for cropping are generally located near rivers on alluvial soils[3] of moderate fertility (Martínez and Sandoval 1993).

Maize (*Zea mays* spp. mays) is the dominant crop in the valley, where it is planted during the rainy season from June to November and also under irrigation in the dry season extending from December to May. Farmers surveyed in Cuzalapa obtained mean maize yields of 2.8 t/ha (unshelled) during the rainy season and 2.1 t/ha (unshelled) in the dry season (under irrigation). Pumpkin is the primary associated crop for more than half of the survey farmers during the rainy season. In the dry season, the majority of survey farmers intercrop beans with maize. Irrigation and intercropping are not new practices in the area: they were reported to be a feature of agriculture in Cuzalapa in pre-colonial times (Laitner and Benz 1994). Until commercial opportunities disappeared in the 1970s, flooded rice was also cultivated during the rainy season. Extensive cattle raising is now emerging as a commercial activity.

Each year, about 1,000 ha may be sown in Cuzalapa; of this area, 600 ha are irrigated (Martínez and Sandoval 1993). The average area planted to maize per farmer is about 2 ha in the rainy season and more than 2 ha in the dry season (Table 1). The dry season is the most important cropping season because it involves fewer climatic risks than the rainy season; for example, violent winds in the rainy season can cause major crop losses due to lodging. During the dry season, irrigated maize, beans (*Phaseolus vulgaris* var. bayo and bayo berrendo), and small quantities of green tomato (*tomatillo*, or *Physalis philadelphicum*, which grows spontaneously) can be harvested on the same field.

Cultural practices have evolved in Cuzalapa but continue to be relatively traditional when compared to those found outside the Sierra de Manantlán (Table 1). Farmers generally till the soil with horse-drawn plows in the rainy season. Tractors are used more frequently during the dry season because the economic returns to maize production in that season are greater and more reliable, and the irrigable

2 Communally held agricultural land.
3 These soils are Fluventic Hapludolls and Tipic Udifluvents, according to the U.S. Department of Agriculture Soil Conservation Service classification.

soils contain fewer rocks. Weeds are usually controlled by horse-drawn cultivator before sowing and one month after sowing. Sowing, fertilization, and harvesting are always manual operations. The irrigation technique, which is a very old one, is based on gravity. Farmers construct canals from the river to the field before planting and inside the field during cultivation. Water is conducted through the field by closing or opening furrows or secondary canals.

Beans are produced exclusively for home consumption. Part of the annual maize crop and almost all of the *tomatillo* crop of Cuzalapa are sold outside the valley, yet the Cuzalapa community is poorly integrated into commercial markets. Based on its farming and socioeconomic characteristics, Cuzalapa can be considered representative of many indigenous, poor, and isolated rural areas in Mexico. Cuzalapa is one of the many traditional communities which are being drawn slowly into commercial marketing systems while maintaining features of indigenous society.

Methods

"Seed lot" and "variety" defined

A "seed lot" consists of all kernels of a specific type of maize selected by a farmer and sown during a cropping season to reproduce that particular maize type. The definition of "variety" or "cultivar" used in this study was also developed from farmers' own practices and concepts. A "variety" is defined as all seed lots held by farmers that bear the same name and are considered by them to form a homogeneous set. A seed lot therefore refers to a *physical unit* of kernels associated with the farmer who sows it, whereas a variety is associated with a *name*.

Table 1. General characteristics of maize cultivation in Cuzalapa, Mexico (mean data; maximum and minimum in parentheses)

	Rainy season, 1989 (Surveyed fields = 21)		Dry season, 1990 (Surveyed fields = 19)	
Cultural practices				
Tractor use (% farmers)	27		74	
Chemical fertilizer use (% farmers)	86		89	
Quantity of fertilizer applied (kg N/P/K per ha)	86-3-0	(0-226/0-30/0-7)	78-0.5-0	(0-129/0-8/0-8)
Insecticide use (% farmers)	43		16	
Herbicide use (% farmers)	14		0	
Maize				
Area sown per farmer (ha)	1.9	(0.2-7.9)	2.6	(0.4-6.8)
Number of maize varieties sown per farmer and per cycle	2.6	(1-6)	2.4	(1-7)
Seed germination (%)	80	(66-93)	65	(47-73)
Plant density (1000 plants/ha)	45.0	(32.5-66.8)	34.1	(20.0-52.3)
Number of ears produced per plant	0.65	(0.27-0.91)	0.68	(0.46-0.93)
Maize yield (kg ears/ha)	2,830	(1,180-4,510)	2,120	(1,290-3,950)
Associated crop	**Pumpkin**		**Bean**	
Percentage of farmers planting	57		84	
Mean density (1000 plants/ha)	1.0	(0.4-1.6)	179	(42-263)

Source : Louette (1994).

A maize variety is defined as "local" when seed from that variety has been planted in the region for at least one farmer generation (that is, for more then 30 years or if a farmer maintains that "my father used to sow it"). This definition implies that a local variety has been cultivated continuously among survey farmers in Cuzalapa for many years. By contrast, a "foreign" variety is characterized either by the recent introduction of its seed lots or by episodic sowing in the valley. Landraces are farmers' varieties which have not been improved by a formal breeding program. Foreign varieties may include landraces from other regions and commercial improved varieties recently or repeatedly reproduced by farmers using traditional methods.

Documenting the exchange of seed and varieties

To document which maize varieties are cultivated and to record the exchange of seeds and varieties in the community and between the valley of Cuzalapa and other regions, 39 farmers were surveyed during six cropping seasons covering three calendar years (the 1989, 1990, and 1991 rainy and dry seasons). For each farmer and cropping season, data were collected on varieties cultivated and seed source. Cultivars included those grown on the farmer's own fields, those grown on rented fields, and those grown on fields in association with other farmers. Each variety was registered with the name given by the farmer. When seed was introduced from another region and bore the same name as a local variety, farmers were consulted about whether or not the seed should be differentiated from the local material. When the seed shared the same name as a local variety but was not considered by the farmer growing it to be the local variety, a second label was noted in brackets — for example, "*Negro* [Foreign]."

The seed source was classified in three ways: (1) as own seed (seed selected by the farmer from his own harvest); (2) as seed acquired in Cuzalapa (seed obtained in the valley of Cuzalapa from another farmer); and (3) as an introduction (seed acquired outside of the Cuzalapa watershed). The origin of a seed lot is defined independently of the origin of the previous generation of seed. A seed lot is considered "own seed" if the ears from which the kernels were selected were harvested by the farmer in his field in Cuzalapa, even though the seed that produced those ears (i.e., the previous generation of seed) may have originated in another region. The data therefore represent well the extent of seed exchange, but they understate the importance in Cuzalapa of seed with foreign origin.

Measuring morphological diversity

The structure of phenotypic diversity was studied both within a variety (among seed lots of a variety) and among varieties (among sets of seed lots bearing different names). Fourteen of the twenty-six cultivars identified by farmers were selected for analysis based on their origin (all six local varieties and eight foreign varieties) and seed availability. The number of seed lots per cultivar (one to six) varied according to the importance of the cultivar in terms of planted area.

Morphological descriptors were measured in a controlled experiment of maize grown in pure stand in three complete blocks. The experiment was established in a farmer's field during the 1991 dry season. Each elementary plot (one seed lot) contained six rows, 5 m in length and separated by 0.75 m, which conforms to the spacing most commonly used by farmers in the study region. Seed for each plot was taken from 100 ears (2 grains per ear) selected by the owner. Descriptors were measured using a sample of 20 plants and 15 ears per elementary plot, and refer to characteristics of the vegetative parts, tassel, and ear (see Table 2).[4]

Factorial Discriminant Analysis (FDA) and Hierarchical Cluster Analysis (HCA) (STATITCF program) were used to analyze diversity among the seed lots within varieties and among varieties. Factorial Discriminant Analysis distinguishes seed lots (or varieties) based on the variables for which the ratio of the sum of squared differences within a lot (or a variety) to the sum of squared differences among lots (or among varieties) is greatest. Hierarchical Cluster Analysis ranks lots (or varieties) based on the mean of the weighted Euclidean distances among their center of gravity coordinates on the first five axes identified by the results of the FDA analysis. All variables were used in the FDA-HCA analyses except flowering date, grain color, and 1-grain weight obtained at the sample level (not at the plant level).

Table 2. Vegetative, tassel, and ear descriptors measured in the maize genetic diversity study, Cuzalapa, Mexico

Vegetative descriptors	
HPL	Plant height
HEA	Ear height
DIA	Stalk diameter
LLE	Length of the leaf of the superior ear node
LLE	Width of the leaf of the superior ear node
NLE	Number of leaves above the superior ear, including the leaf of the superior ear node
Tassel descriptors	
LTA	Tassel length
PED	Peduncle length
LBR	Length of the branched part of the tassel
BR	Total number of branches
Ear descriptors	
LEA	Ear length
WEA	Ear weight
DEA	Ear diameter
WCO	Cob weight
DCO	Cob diameter
ROW	Number of rows of grain
HGR	Grain height (3 grains mean)
WGR	Grain width (10 grains mean)
TGR	Grain thickness (10 grains mean)
W1G	1-grain weight (3 samples of 100 grains)

Cultivars and Seed Exchange

Cultivars

As noted earlier, during the six seasons covered by the survey, survey farmers grew a total of 26 varieties (Table 3). Each farmer grew between one and seven maize varieties during each season and, on average, more than two varieties per season (Table 1). Most of these cultivars are white-grained dents with a floury texture and are used primarily for making *tortillas,* the starchy staple of the Mexican diet. Three flinty popcorn varieties (Guino Rosquero, Negro [Guino], and Guino Gordo) were also identified, as well as three purple-grained varieties (Negro, Negro [Foreign], Negro Guino) and three yellow-grained varieties (Amarillo Ancho, Amarillo, Amarillo [Tequesquitlán]). The purple varieties are considered sweeter and are generally consumed roasted at the milky stage, while the yellow varieties are used essentially as feed for poultry and horses.[5]

[4] The flowering dates of the different seed lots were also determined by computing regularly the number of plants in the male flowering (MF) or female flowering (FF) stage. The flowering dates, grain color, and weight per 100 grains were recorded at the plot level, whereas the other descriptors were measured on each plant and ear of the sample.

[5] Farmers associate yellow grain color with richness of oil, a characteristic that interests them for animal feed. The yellow varieties are not often used as human food because *tortillas* made from yellow maize are yellowish — as if they had been made with white maize, but using too much lime.

Some varieties have particular agronomic characteristics. For example, the variety Blanco matures early and can be harvested early to free the field for the next cropping cycle. Varieties with a short growing cycle are grown primarily in the dry season because of water shortages toward the end of the season (81% of the Blanco area was planted in the dry season). Varieties having a longer growing cycle, such as Chianquiahuitl, are generally planted in the rainy season as they are more productive during this season than varieties with a short growing cycle (72% of Chianquiahuitl area was planted in the rainy season). The Amarillo Ancho variety is considered more productive than Blanco on piedmont soils. Enano and Enano Gigante are considered suitable for rainy season production because their thick stalks enable them to resist the strong August winds.

Of the 26 varieties grown by farmers, only six can be considered local based on the definition used in this study, and all of these are related to the Tabloncillo race (Table 3). In other words, only the cultivars Blanco, Chianquiahuitl, Tabloncillo, Perla, Amarillo Ancho, and Negro had been grown continuously for at least one farmer generation in the valley of Cuzalapa. Chianquiahuitl appears to have been introduced 40 years ago, but the date of introduction for the other cultivars is unknown.

Table 3. Relative importance of different maize varieties cultivated in Cuzalapa, Mexico

Variety	Percentage of area planted to maize	Percentage of farmers	Grain color
Local varieties			
White			
Blanco	51	59	White
Chianquiahuitl	12	23	White
Tabloncillo	5	6	White
Perla	0.4	0.02	White
Other color			
Amarillo Ancho	8	23	Yellow
Negro	3	34	Purple
Foreign varieties			
3 most cultivated varieties			
Argentino[a]	5	10	White
Enano[b]	3	12	White
Amarillo[a]	3	11	Yellow
17 minor varieties	>3 per variety	>4 per variety	15 white 1 yellow 1 purple
Tuxpeño, Tampiqueño, Amarillo [Tequesquitlán], Guino Gordo, Guino Rosquero, Negro [Guino], Guino [USA], Blanco [Tequesquitlán], Cosmeño, Canelo, Ahumado, Negro [Foreign], Tosqueño[a]			
Híbrido [Mejorado], Híbrido, Enano Gigante[b]			
HT47[c]			

Source: Louette (1994).

[a] Farmers' varieties (landraces).

[b] Advanced generations of improved varieties.

[c] First or second generation of an improved variety.

Four of the six local varieties are cultivated by a large percentage of farmers. Since two of these varieties have white grain (Blanco, Chianquiahuitl), one has yellow grain (Amarillo Ancho), and the fourth has purple grain (Negro), all four varieties provide for the different household uses of maize in Cuzalapa. Although they are few in number, they dominate the maize area (80%) in the study zone. The two principal white varieties alone occupy an estimated 63% of the area planted to maize. Because of the ways in which the Negro and Amarillo Ancho varieties are used, they are cultivated by a fairly high percentage of farmers (23% and 34%, respectively) in comparison with the percentage of area they occupy (8% and 3%).

The remaining 20 of the 26 varieties that Cuzalapa farmers grew during the survey period are classified as foreign. The composition of this group of varieties changed from season to season. Each foreign variety covered less than 5% of the maize area planted in each season, and most were cultivated by only a few farmers at a time. Only three of these varieties (Argentino, Enano, and Amarillo) had been regularly cultivated over the preceding four or five years by a significant percentage of farmers (10-12%). Most had been used for the first time recently or during the survey period and had been planted again once or twice. Among these, three varieties of the Reventador race are well known and have been introduced episodically in the valley. Over the period of the study, only one cultivar was abandoned by the group of farmers interviewed.

The origin of the foreign varieties is often difficult to ascertain. Farmers are able to indicate in which community they acquired a variety but not its true source. Based on the information collected, foreign varieties can be classified into three groups: farmers' varieties (landraces) (15); farmers' advanced generations of improved varieties (4); and recent generations of improved varieties (1) (Table 3). The group of foreign varieties is morphologically diverse, including white-, yellow-, and purple-grained materials and representatives of different races. Most cultivars were introduced from communities of southwestern Jalisco, less then 100 km from Cuzalapa, although the Guino [USA] variety cultivated by one farmer originated in the United States. The origin of the improved cultivars in the group of foreign varieties is even more difficult to identify, especially if they were not directly obtained through credit or they have been replanted for numerous cycles in Cuzalapa (as, for example, the Enano variety). Information about the source of the variety and even its original name can often disappear or take on a different meaning when farmers exchange seed: survey farmers believed that the Argentino variety came from Argentina, based on its name only.

In general, the data indicate that although the varieties defined as "local" occupy most of the cultivated area, maize cultivation in Cuzalapa depends not only on local materials but also on a changing and diverse group of foreign varieties introduced through farmer-to-farmer exchanges. The next section explains how, in addition to exchanging the varieties themselves, farmers exchange particular lots of seed.

Seed exchange

By detailing the geographical origin of each farmer's seed lots, for each variety, in each planting cycle, the frequency of seed exchange among farmers can be identified and the pattern of varietal diffusion can be characterized. During the study period, the survey farmers sowed maize in six cropping cycles on 442 ha. For the total of 26 varieties they cultivated, survey farmers planted 484 seed lots (Table 4, Figure 2).

Many of these seed lots came from other farmers or regions. On average, for all cropping seasons, survey farmers selected slightly over

Table 4. Origin of seed lots used in Cuzalapa, Mexico (by variety)

Variety	Number of seed lots	Own seed lots		Seed lots acquired in Cuzalapa Valley		Seed lots acquired in another community	
		(No.)	(%)	(No.)	(%)	(No.)	(%)
Local varieties							
Blanco	139	67	48.2	51	36.7	21	15.1
Negro	79	57	72.2	21	26.6	1	1.3
Amarillo Ancho	54	25	46.3	26	48.2	3	5.6
Chianquiahuitl	53	39	73.6	14	26.4	0	0.0
Tabloncillo	14	8	57.1	5	35.7	1	7.1
Perla	3	2	66.7	0	0.0	1	33.3
Total	342	198	..	117	..	27	..
Mean	..	..	57.9	..	34.2	..	7.9
Foreign varieties							
Major varieties							
Amarillo	26	13	50.0	11	42.3	2	7.7
Enano	27	12	44.4	14	51.9	1	3.7
Argentino	23	7	30.4	15	65.2	1	4.3
Total	76	32	..	40	..	4	..
Mean	..	..	42.1	..	52.6	..	5.3
Minor varieties							
Híbrido [Mejorado]	11	1	9.1	7	63.6	3	27.3
Tuxpeño	8	1	12.5	0	0.0	7	87.5
Amarillo [Tequesquitlán]	6	5	83.3	0	0.0	1	16.5
Híbrido	5	5	100.0	0	0.0	0	0.0
Enano Gigante	5	2	40.0	2	40.0	1	20.0
Guino Gordo	5	2	40.0	1	20.0	2	40.0
Guino Rosquero	4	2	50.0	0	0.0	2	50.0
Negro [Foreign]	4	1	25.0	3	75.0	0	0.0
Blanco [Tequesquitlán]	3	2	66.7	0	0.0	1	33.3
Guino [USA]	3	2	66.7	1	33.3	0	0.0
HT47	3	2	66.7	0	0.0	1	33.3
Cosmeño	2	0	0.0	1	50.0	1	50.0
Tampiqueño	2	0	0.0	0	0.0	2	100.0
Canelo	2	0	0.0	1	50.0	1	50.0
Ahumado	1	1	100.0	0	0.0	0	0.0
Negro [Guino]	1	0	0.0	0	0.0	1	100.0
Tosqueño	1	0	0.0	0	0.0	1	100.0
Total	66	26	..	16	..	24	..
Mean	..	..	39.4	..	24.2	..	36.4
TOTAL	484	256	..	173	..	55	..
MEAN	..	..	52.9	..	35.7	..	11.4

Source: Louette (1994).

half (53%) of their seed lots from their own harvest. About 36% of the seed lots were obtained from another farmer in Cuzalapa, and 11% were introduced from other regions. Calculated in terms of area planted, seed from farmers' own harvests represented 45% of the maize area in the study zone, whereas 40% was planted to seed from other Cuzalapa farmers and 15% was planted to foreign introductions. Seed exchange — whether between farmers inside the valley or with farmers outside the valley — is clearly very important.

The pattern of varietal diffusion

Both local and foreign varieties were planted from farmers' own seed lots, seed lots acquired in Cuzalapa, and introduced seed lots, but in different proportions. Significant differences in origin were associated with the dominance of the variety in terms of planted area. Seed of the most widely grown varieties — including the local varieties and the three most important foreign varieties — is less likely to have been obtained from farmers outside Cuzalapa than seed of the more minor foreign cultivars (7.9% of local and 5.3% of important foreign seed lots were introduced, compared to 36% of minor foreign seed lots) (Figure 2).

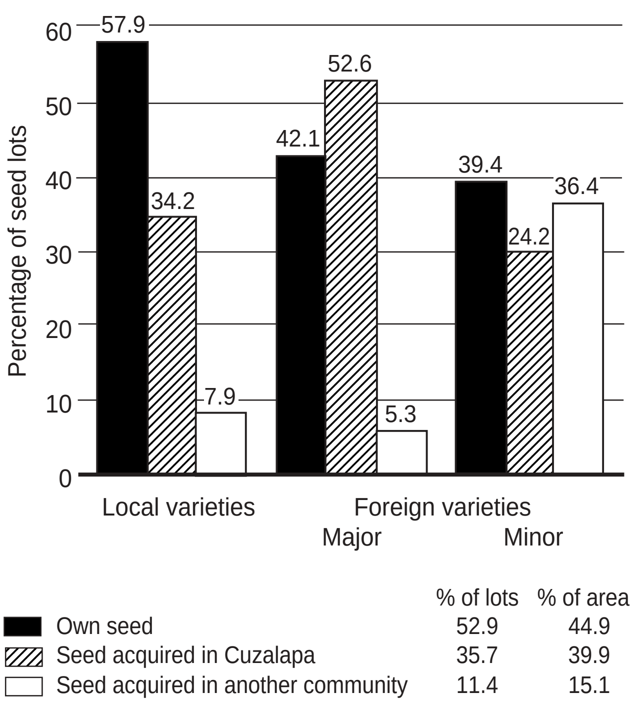

Figure 2. Origin of maize seed planted in Cuzalapa, Mexico, by origin of variety (29 farmers, 6 cropping cycles).

Seed of local varieties is essentially reproduced by each farmer. Among local varieties, seed for Chianquiahuitl and Negro is managed more conservatively; more than 70% of the seed for these varieties is selected from farmers' own maize harvests (Table 4). In fact, farmers plant such a small area to the variety Negro that, on average, seed equivalent to only 27 ears is required per farmer (Louette 1994). This amount of seed, in good condition, is carried over easily from one cycle to the next, and farmers do not need to seek out seed from another farmer. Chianquiahuitl is a variety of unknown origin that is no longer believed to be widely cultivated outside the study zone, so of necessity farmers in the Cuzalapa Valley must rely on their own stocks.

The case of Blanco contrasts with that of Chianquiahuitl. Of all the local varieties, Blanco has the highest proportion of seed obtained from farmers outside the study zone (15%). This result reflects the importance of Blanco in terms of area cultivated in Cuzalapa and regions nearby. Because Blanco is important for household subsistence, an insufficient number of ears suitable for seed may remain at planting time. Farmers then search for seed from other farmers in and outside the community. In fact, the data suggest that an informal contractual relationship may exist between farmers in Cuzalapa and in Chacala, located 30 km away. Of the 21 lots of seed for the variety Blanco introduced during the study period, about half (11) originated in Chacala, and nine of them were sown in the dry season. On the other hand, Chacala farmers come to Cuzalapa to obtain seed to plant Blanco in the rainy season (there is no irrigation in Chacala).

Although the percentage of seed brought from other regions is small for the most widely grown foreign varieties, farmers in the valley exchange seed of these varieties quite frequently (Figure 2). These varieties were introduced some years ago, and because they have demonstrated characteristics of value, their seed is redistributed to other farmers in Cuzalapa. For example, increasing interest in the variety Argentino was observed during the study period, and farmers acquired 65% of the seed for this variety from other farmers in the study zone (Table 4).

The situation is less clear for foreign varieties that are minor in terms of cultivated area. Each variety appears to be a special case defined by the time of its introduction and the number of farmers planting it. For some of the varieties introduced late in the survey period, all seed lots were introduced. On the other hand, because farmers test foreign varieties over several seasons, reproducing them locally, 39.4% of the seed of introduced varieties was selected from farmers' own harvests. Relative to the major foreign varieties, the proportion of seed of minor foreign varieties that was obtained from other farmers in Cuzalapa is small. Presumably, survey farmers who did not plant these varieties during the study period are not yet convinced of their advantages.

In summary, there is a moderate level of diffusion of local varieties inside the watershed and little infusion from other regions. Recently introduced foreign varieties are infused from outside the valley. Older foreign varieties that have attained a moderate level of acceptance are also diffused inside the watershed. The pattern of diffusion of the varieties is therefore linked essentially to the local acceptance of the variety, the time it has been sown in the region, and the availability of seed inside and outside the region.

Farmer type

The general patterns of maize seed exchange that we have just described nevertheless conceal major differences among survey farmers. At one extreme are the farmers who use seed selected from their own maize harvests almost exclusively from one season to the next (Figure 3). At the other end of the spectrum are farmers who have never used their own seed lots. An intermediate group of farmers use their own seed and seed from other sources.

Farmers who almost always use their own seed lots sow the same varieties regularly and only modify the proportion of maize area planted to

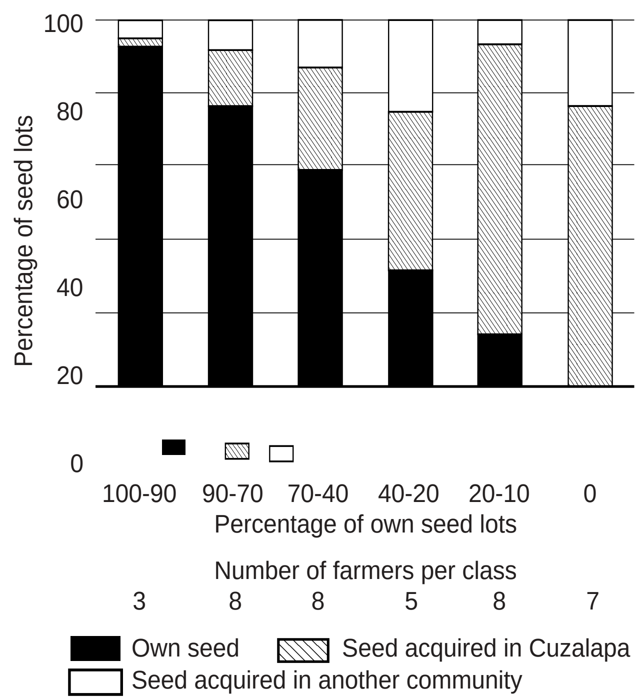

Figure 3. Classification of the 39 farmers surveyed in Cuzalapa, Mexico, by the origin of their maize seed (6 cropping cycles).

each variety in each cropping season. These farmers are considered suppliers of seed of local cultivars ("they always have seed").

Other farmers use their own seed lots as well as seed acquired in the community or introduced from other regions, and the proportions of each type of seed vary from season to season depending on each farmer's objectives and constraints. These farmers are generally regarded as suppliers of introduced seed, and some are known in the community for their curiosity about new varieties.

The farmers who used almost no seed from their own maize harvests had recourse throughout the study period to seed acquired within and outside the Cuzalapa community. This group of farmers includes those who do not have rights to land and cannot plant maize each season and those who farm small areas on which they cannot harvest enough maize for both family consumption and seed. Farmers in this group are obliged to look for seed from other farmers when they want to plant maize.

A relation exists between the number of varieties (different seed lots) sown by each farmer in each cycle and farmer type. The correlation coefficient between the number of varieties per cycle and the proportion of the farmer's seed stocks originating from his own harvest is 0.5. In general, farmers who have more recourse to seed produced by other farmers appear to plant fewer varieties per cycle. The group of farmers who sowed more than 90% of their crop with seed from their own harvests planted an average of 2.6 varieties per cycle, while those who used no seed from their own harvests planted an average of only 1.3 varieties per cycle. This finding may reflect either a greater reliance on diverse maize types by more conservative farmers, or it may reflect the fact that searching for seed from other farmers requires more effort and is therefore associated with fewer varieties sown.

Factors explaining seed exchange

Several factors induce farmers to exchange seed. The first is the traditional method of seed storage. Maize (for seed and for food) is stored in bulk in a room of the house. Ears are often attacked by weevils and other insects when the grain is stored for longer than six months (from one dry season to another dry season, for example). If a farmer sows a particular variety in only one season per year and has not sown that variety in the previous year, or if the cropping calendar obliges him to plant before harvest, he will search for seed from ears that have been harvested more recently by other farmers. The dry season is better for providing seed because more area is cultivated. Either as a percentage of area planted or as a percentage of total seed stocks, the interchange of seed is more evident at the end of the rainy season. For example, farmers' own maize harvests provide 32% and 57% of the seed for Blanco and Chianquiahuitl grown in the dry season and 69% and 81% of the seed for these varieties during the rainy season.

A second important factor affecting the importance of farmers' seed sources in planting decisions is the socioeconomic status of the household, as represented by farm size, land use rights, and access to the market for renting land. As noted above, many farmers do not cultivate an area large enough to meet their annual food consumption needs, whereas others own no land and must rent a field to cultivate maize. These farm households often consume all of one season's production before planting and are obliged to search for seed each season.

Another factor influencing the seed sources used by farmers is the custom in the Cuzalapa region of producing maize under sharecropping arrangements. Under these arrangements, the partner (or *mediero*) generally supplies labor while the field owner (or *patrón*) supplies the inputs — in particular, maize seed. Generally the *mediero* does not choose which varieties to plant, and at harvest time acquires seed from the *patrón*, who is recorded in this study as "another farmer of the region." Seed is also loaned, under the proviso that double the quantity of seed loaned must be returned at harvest. In either case, the farmer obtains maize seed of a variety that another farmer has chosen to grow and that is derived from another farmer's harvest.

Another finding from the survey is that few farmers expressed any particular preference for or allegiance to their own maize as a source of seed. Seed of a given variety selected from their own maize harvest or acquired from other farmers was considered equivalent. In other words, another farmer's method of seed management was not a cause for concern. Furthermore, if a farmer does not grow a particular variety for several successive seasons, this does not signal that the farmer has ceased cultivating it altogether, as long as the seed for that cultivar can still be obtained from other farmers if necessary. Farmers also generally consider that they must change seed regularly to maintain the productivity of the variety ("sow the same maize type but from new seed"). The frequency of seed renewal varies from several cycles to several years. It appears unlikely that any farmer in Cuzalapa sows seed derived from a stock bequeathed directly from his parents.

Finally, farmers appeared to be very curious and open-minded, in general, about testing new cultivars. After visiting a relative or friend, or after harvesting a maize field as a laborer, a farmer often returns with maize ears so that he can test a variety whose ear characteristics he admires. The introduced seed lots acquired from other farmers are almost never bought as seed. They are gifts from friends or family members living outside the zone or are selected from maize cobs bought for consumption.

Phenotypic Diversity of Varieties

The patterns of maize production and seed management described above are characterized by continual introductions of varieties and, within varieties, considerable exchange of seed among farmers. These findings raise questions about the structure of maize diversity in the Cuzalapa watershed. For example, how can an introduced seed lot be integrated into a local variety? Do foreign varieties compete with local varieties or are they complementary? Analyses of the phenotypic diversity of maize grown in Cuzalapa provide a way to examine some of these questions.

Phenotypic characteristics and varietal identification

With the exception of the B1 lot of the Blanco variety, the HCA analysis of seed lots for the five most important varieties (four locals and one foreign) demonstrates that seed lots bearing the same name cluster together based on their morphological characteristics (Figure 4).[6] The results support the hypothesis that farmers' concept of a variety corresponds closely to that of a phenotype. A farmer variety is a set of seed lots having the same name; these seed lots

[6] If grain color had been used as a variable in the analysis, the seed lots of the Amarillo Ancho (AA) and Negro (N) varieties that now appear within this group would have been differentiated.

produce maize with similar plant, tassel, and ear characteristics.

The implication of these findings is that when farmers in Cuzalapa classify seed as that of a given variety they use morphological and phenological criteria rather than criteria such as geographic origin, adaptation to some limiting factor, or ritual function. A seed lot that resembles seed of a "local" landrace is classified as such by the farmer, even though its origin may be foreign or unknown. As a consequence, some seed lots of "local" landraces are in fact introduced from other regions. Furthermore, the composition of the group of seed lots that constitute a variety is mutable over time.

Phenotypic variation between varieties

The phenotypic characteristics of six local varieties and eight foreign cultivars (including the three most widely cultivated) were studied with the methods described above (Table 5). The data reveal a large amount of phenotypic diversity with respect to several characters. For example, the sum of degree days from sowing to tasseling varied from 1,130°C for the earliest maturing variety, Blanco, to 1,550°C for the latest maturing variety, Argentino (Blanco required 77 days to reach maturity during the 1991 dry season and Argentino required 96 days). Mean height of the ear varied from 129 cm to 195 cm, the number of rows of grain varied from 8.7 to 12.7, the grain width from 0.85 cm to 1.13 cm, the cob diameter from 1.8 cm to 2.7 cm, and the ear weight from 104 g to 181 g.

In the varieties studied, 78% of the variability in phenotypic characteristics was explained by the first two axes of the FDA (Figure 5). The first axis is essentially defined by row number (-ROW), grain width (+WGR), plant height (-HPL), and ear height (-HEA). The second axis is determined by ear development, including the weight and diameter of the cob (+WCO, +DCO) and weight

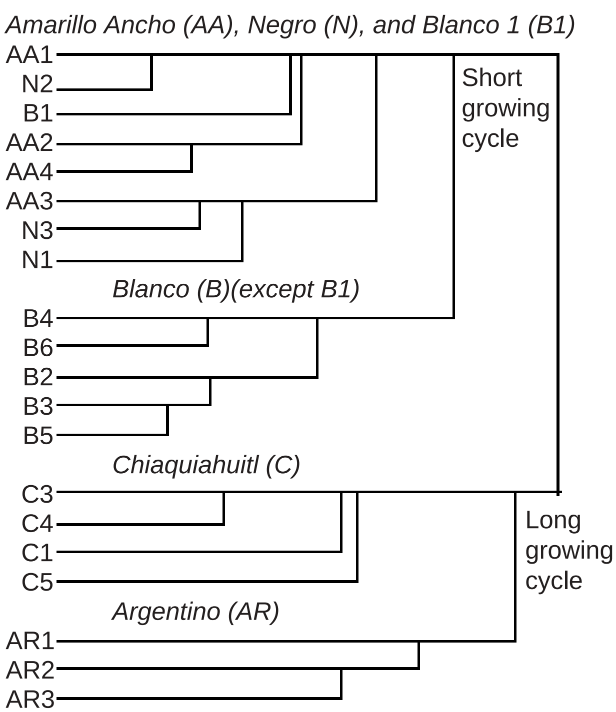

Figure 4. Hierarchical Cluster Analysis of seed lots of five varieties by phenotypic characteristics.

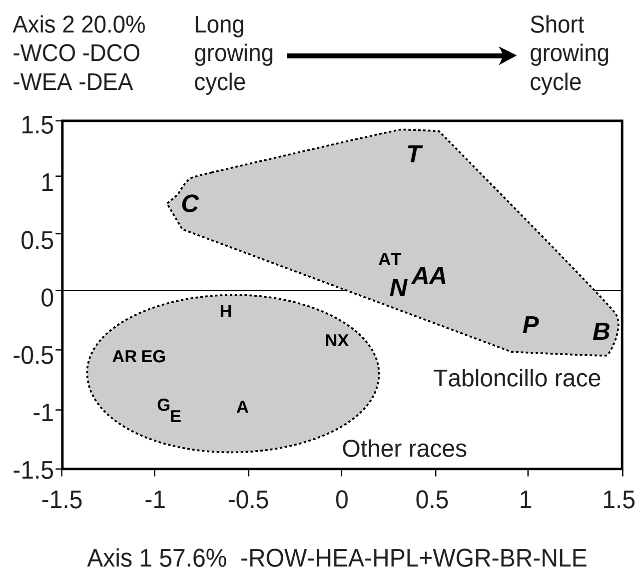

Figure 5. Phenotypic diversity of maize varieties planted in Cuzalapa, Mexico: Factorial Discriminant Analysis of vegetative, tassel, and ear characteristics, axes 1 and 2.

Note: Local varieties in large characters; key to descriptors and varieties in Tables 2 and 5.

and diameter of the ear (+WEA, +DEA). A test comparing farmers' methods for identifying varieties and these two axes indicated that the statistical analysis and farmers classify maize varieties in a similar way (Louette 1994).

The descriptors listed above facilitated the differentiation of varieties in two ways: by duration (length of growing cycle) and by origin or race. These characteristics were not included as variables in the analysis because they characterize each seed lot but not each plant or ear, but they were closely related to some descriptors that define the first two axes of the FDA. Duration is highly correlated with descriptors for the first axis (r>0.80 between male flowering date and HEA, NLE, WGR, ROW). A long-duration variety is characteristically a taller plant that has more leaves and smaller grains arranged in more rows.[7]

The origin of a variety (local or foreign) also relates to differences in phenotypic characteristics. The only exception to this general rule is the variety Amarillo [Tequesquitlán] (AT), which is associated with the local varieties even though it was introduced from a community located some 20 km from Cuzalapa. The local

Table 5. Principal characteristics of the 14 varieties studied in Cuzalapa, Mexico (local varieties in boldface type)

Variety	MF (days)	HEA (cm)	HPL (cm)	NLE	WLE (cm)	BR	ROW	WGR (cm)	TGR (cm)	WCO (g)	DCO (cm)	WEA (g)	DEA (cm)	W1G (g)
							Short duration							
Blanco (B)	**77.3**	**129**	**219**	**5.9**	**7.9**	**16.1**	**8.7**	**1.13**	**0.40**	**19.7**	**2.1**	**140**	**4.0**	**0.42**
							Intermediate duration							
Perla (P)	**82**	**144**	**235**	**6.1**	**8.1**	**16.9**	**8.7**	**1.08**	**0.39**	**18.7**	**2.2**	**128**	**3.9**	**0.38**
Amarillo Ancho (AA)	**82**	**146**	**231**	**6.1**	**7.9**	**19.3**	**9.8**	**1.00**	**0.39**	**19.8**	**2.2**	**126**	**3.9**	**0.33**
Amarillo [Teq.] (AT)	82	160	242	6.2	7.8	20.8	9.6	0.99	0.38	17.5	2.1	123	3.9	0.35
Negro (N)	**83.2**	**156**	**232**	**6.3**	**7.9**	**19.8**	**10.0**	**0.97**	**0.37**	**18.1**	**2.2**	**123**	**3.9**	**0.31**
Tabloncillo (T)	**85**	**145**	**230**	**6.2**	**7.7**	**19.2**	**9.3**	**0.95**	**0.33**	**12.0**	**1.8**	**104**	**3.6**	**0.29**
							Long duration							
Negro [Foreign] (NX)	91.5	171	232	6.1	8.2	20.5	10.2	1.00	0.38	23.1	2.4	126	4.0	0.31
Híbrido (H)	92	179	254	6.3	8.1	20.4	11.9	0.91	0.37	22.0	2.3	141	4.2	0.30
Amarillo (A)	92	185	261	6.6	8.1	19.8	11.3	0.99	0.38	27.3	2.6	164	4.4	0.36
Enano (E)	92.5	161	231	6.8	8.5	23.2	13.4	0.89	0.40	29.7	2.7	160	4.5	0.31
Guino (G)	92.5	174	249	6.5	8.6	20.0	12.7	0.94	0.36	30.1	2.7	181	4.6	0.34
Chianquiahuitl (C)	**93.2**	**188**	**260**	**6.2**	**7.8**	**21.5**	**11.7**	**0.85**	**0.34**	**17.6**	**2.1**	**126**	**3.9**	**0.27**
Enano Gigante (EG)	93.5	185	261	6.6	8.4	20.5	12.4	0.93	0.36	26.2	2.6	158	4.4	0.32
Argentino (AR)	96	195	273	6.5	8.4	22.8	12.6	0.92	0.36	26.2	2.5	158	4.4	0.32

Source: Louette (1994).
Note: MF = male flowering date; HEA = ear height; HPL = plant height; NLE = number of leaves above the superior ear, including the leaf of the superior ear node; WLE = width of the leaf of the superior ear node; BR = total number of branches of the tassel; ROW = number of rows of grain; WGR = grain width (10 grains mean); TGR = grain thickness (10 grains mean); WCO = cob weight; DCO = cob diameter; WEA = ear weight; DEA = ear diameter; and W1G = 1-grain weight (3 samples of 100 grains).

[7] Length of growing cycle is, as expected, significantly different between the short-duration and long-duration groups of varieties (p<5%).

varieties are characterized by narrower, lighter ears and less vegetative development than the foreign varieties (Table 4). They and Amarillo [Tequesquitlán] are related to the Tabloncillo race, which originated on the Pacific Coast of Mexico (Wellhausen et al. 1952). The foreign varieties included in the trial (excepting AT) are linked to other races. Origin is therefore related to variation in race.

Origin and duration are also interrelated. Most of the varieties with long growing cycles are foreign, with the exception of Chianquiahuitl. In Cuzalapa, therefore, local and foreign varieties appear to be complementary from a morphophenological point of view. Most local varieties have a short growing cycle, reduced vegetative development, few rows, and large kernels, whereas introduced varieties have a long growing cycle, taller plants, and small kernels.

There are three possible explanations for the fact that foreign varieties in Cuzalapa almost all have long growing cycles, whereas local varieties have short ones. The first is that in Cuzalapa today, varieties with a short growing cycle are grown primarily in the dry season and long-cycle varieties are generally planted in the rainy season. Until the 1970s, flooded rice was cultivated during the rainy season and maize was sown almost exclusively during the dry season. The local landraces were then generally early maturing. The longer growing cycles of foreign varieties may reflect the fact that maize began to be cultivated during the rainy season only recently.

Another explanation for the close relationship between length of growing cycle and foreign origin is that few landraces in the region around the Cuzalapa Valley mature early, because outside Cuzalapa the major cropping cycle is the rainy season. On the other hand, few early maturing improved varieties have been developed for the lowland tropical zones where most maize is produced in developing countries; one of CIMMYT's objectives is to develop materials with such characteristics (CIMMYT 1993).

Finally, the complementary characteristics of local and foreign varieties may be interpreted in yet a different way. When a lot of seed introduced from another community has the same phenotypic characteristics as seed of a local variety, farmers may consider it as seed of a local variety. The new seed would be identified by the name of the local variety and would no longer be distinguishable from it. For example, all introduced seed of maize with short, thick stalks is named Enano after the first foreign variety that had that kind of stalk. Farmers appear to use different names only for seed lots with particular characteristics of interest for them. No introduced seed lot that is morphologically similar to a local variety would be distinguished, so no foreign variety with characteristics similar to those of local varieties would be recognized as a distinct cultivar.

Discussion

In the Cuzalapa region, farmers cultivate a large number of varieties that are diverse with respect to vegetative characteristics, ear characteristics, and length of growing cycle. Phenotypic diversity seems to be an adaptation to the opportunity in Cuzalapa of producing maize during two seasons each year, each with distinct pedoclimatic conditions. It also reflects the diverse uses of maize and multiple objectives of farm households in the region. The observations reported here confirm the widespread image of great diversity and multiple production strategies in traditional cultural systems (Merrick 1990, Toledo 1990).

The assumption that traditional systems are closed and isolated with respect to the flow of genetic material is clearly contradicted, however, by the results of this study. The group of maize varieties cultivated by farmers in the traditional community of Cuzalapa changes in composition over time. A small group of local landraces is continuously cultivated, while varieties with diverse origins that are morphologically diverse among themselves and distinct from the local landraces succeed each other over time. These foreign varieties are introduced for testing by farmers, but they may also be integrated into the group of local landraces.

Rather than displacing local cultivars, foreign varieties occupy a small proportion of the area planted to maize, and local landraces continue to dominate maize area in Cuzalapa. Similar results have been reported by researchers investigating the use of rice (Dennis 1987), maize (Ortega 1973), and potato varieties (Brush et al. 1981) in their regions of origin. Introduced varieties more often have uses and modes of management that are complementary, rather than substitutable for, those of the dominant cultivars (Berard et al. 1991). In Cuzalapa the morphophenological characteristics of the local and foreign varieties seem complementary, and the two groups rarely compete with respect to growing cycle, vegetative characteristics, or ear attributes. Introductions do not necessarily lead to a large shift away from local cultivars. This finding suggests that a variety is more easily adopted by farmers if it satisfies a need that is not currently met by local varieties or if it occupies a place in the morphological continuum that has not yet been exploited (Boster 1985). In Cuzalapa, survey farmers clearly sought new or different genetic materials from among foreign varieties.

At the level of introduction observed in Cuzalapa, foreign varieties are more a source of phenotypic diversity than a cause of genetic erosion. As indicated by Brush (1992), genetic erosion seems to be a phenomenon that is too complex to be captured in the equality "introduction of varieties = loss of genetic diversity." Genetic erosion is a complex function of the area occupied by introductions versus area planted to local cultivars, the diversity within and between the introductions and local cultivars, and the extent to which local varieties have been abandoned or substituted. As long as the function of the introduced material is complementary to that of the local germplasm, diversity probably increases. When the introduced and local materials compete, foreign varieties can displace local material, but this displacement necessarily leads to a loss of diversity only if the introduced material is less diverse or replaces several local landraces. Identifying accurately the factors that affect the extent of genetic erosion, and determining their critical values, is likely to be difficult, and especially so in a system as dynamic as that of Cuzalapa.

Research findings have implications for how and when adoption occurs. The regular introduction of genetic material by farmers is evidence of their curiosity about, rather than resistance to, the introduction of new cultivars. In Cuzalapa, farmers are generally experimenters who do not hesitate to test new cultivars they have seen planted by farmers in other regions against their dominant local varieties. Farmers will adopt a maize variety, however, only if it demonstrates its advantages consistently over a large number of cropping seasons. One trial with bad results can lead a farmer to abandon a variety, regardless of the reason for the failure. During the last 40 years, of all of the varieties introduced by the survey farmers of Cuzalapa, only Chianquiahuitl has been adopted. Brush et al. (1981) have also indicated that in the Mantaro Valley in Peru farmers may travel more than 50 km in search of new potato varieties. In Dennis' (1987) study in Thailand, the average farmer in the eight villages cultivated 10 varieties in the first year, adopted four introduced varieties in five years, and abandoned four cultivars during the same period. Dennis characterizes similar situations as an "excess of diversity" with respect to what is necessary to keep the agricultural system functioning.

Another major research finding concerns the definition of a local variety itself. The magnitude of seed exchange among farmers raises questions about farmers' concept of a variety, the meaning of "local," and the distinction between "local" and "foreign" varieties. First of all, in Cuzalapa, it is not only the set of cultivars but also the set of seed lots that constitutes the cultivars that varies in time. A certain number of seed lots disappear in each crop cycle because they are not replanted by the farmer who selected them; on the other hand, one introduced seed lot may evolve into a number of seed lots, once farmers begin to exchange seed. Introduced seed lots that phenotypically resemble seed of local landraces are integrated into them. A farmer variety is therefore mutable in terms of the number, origin, and genetic composition of the seed lots that compose it. In and of themselves, local varieties constitute systems that are genetically open.[8]

The geographical point of reference for the term "local variety" is revealed to be larger than the community itself. The genetic diversity of a variety is traceable to more than the community itself, because seed lots of external origin are regularly added to those of local landraces that are then locally reproduced. This practice may be a means for adding diversity to locally adapted cultivars.

Implications for *In Situ* Conservation

The characterization of the maize farming system in the Cuzalapa watershed as open with respect to genetic material is in contrast with the original model for conserving crop genetic resources *in situ.* This model was based on the belief that the best means for *in situ* preservation of the diversity found in genetic material was to isolate it in space and time by maintaining intact the technical, social, and cultural context in which it occurs (Iltis 1974, Benz 1988). According to this point of view, it is necessary to "freeze" the genetic landscape by fixing its environment in parks or reserves where the cultivation of local varieties would be encouraged and where the introduction of foreign cultivars and of new techniques would be prohibited (Iltis 1974). From this point of view, the evolution of a cultivar is considered to be determined exclusively by the region in which it is cultivated and by the traditions of a rural community (Hernández X. 1988, Benz 1988). Conserving the diversity found in local cultivars therefore requires maintenance of the cultural techniques used by farmers and of the broader social context. Development is therefore counterposed with conservation. The dimensions of the farming system in a region are not perceived as affected by exchange with other communities, nor is a variety perceived as the product of genetic exchange with materials that may or may not be replanted locally.

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[8] One purpose of ongoing research in Cuzalapa is to analyze the concept of a farmer's variety by studying how seed selection and management practices influence genetic structure.

Instead, this case study shows that over three years alone, in a traditional farming system located in what some regard as the geographical center of origin for maize, introduced materials represent a substantial proportion of the maize seed planted. The study further shows that local varieties are not generally the product of exclusively local seed selection and management, because farmers exchange seed of local varieties with other farmers within and outside the region.

The findings raise important questions about the best way to conserve the diversity in crop genetic resources. The appropriate geographic scale over which we can define a variety as "local" becomes a concern. The mechanisms that explain the phenotypic diversity of maize in Cuzalapa suggest that a certain influx of genetic material rather than isolation is occurring. Foreign varieties, as well as introduced seed lots that are then integrated into local varieties, are probably a source of phenotypic and genetic diversity. The Blanco cultivar is not only the result of local seed selection by local farmers but also of selection by farmers and natural selection in other regions (in particular Chacala). It is questionable whether any particular geographic scale would necessarily include all of the factors affecting the variety. The strategy of isolating a region on grounds that introduced seed will displace local varieties or even lead to alterations in their genetic structure seems inconsistent with the mechanisms that generate the diversity we observe in the fields of farmers who cultivate in traditional systems.

Some conservationists may argue that if the community under study reveals these characteristics, it is not traditional, because traditional systems are autarkic. In fact, the characterization of a society or community is normative and relative: a community is traditional only with respect to what is perceived as modern and with respect to other contemporary human groups. In any case, the system of seed exchange that has been described by farmers and observed in Cuzalapa appears "traditional" in the sense that it is customary and long-lived. It is likely that the major findings reported can be generalized to other rural areas of Mexico, because the factors that explain the seed exchange system in Cuzalapa appear neither new nor specific to this region. To be convinced of this point it is enough to observe the extent to which world agriculture in general is the fruit of an ancient and continuous evolution that includes the diffusion of plants from their centers of domestication, the adoption and abandonment of cultivars or of cultivated plants, the differentiation of races and varieties within species, and the adaptation of cultivars to various agrosystems and techniques of cultivation (Haudricourt and Hedin 1987; Harlan 1992).

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