Seed Trade
IN RURAL MARKETS

Implications for Crop Diversity and Agricultural Development



Edited by Leslie Lipper,
Leigh Anderson and Timothy J. Dalton

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Mexico: Maize and Chiapas Case Study

Jon Hellin, Alder Keleman, Mauricio R. Bellon, and Joost van Heerwaarden

Introduction

Maize is an important crop within Mexico and also worldwide. Of the 140 million hectares of maize grown globally, approximately 96 million hectares are in the developing world, where it is grown under a variety of agro-ecological conditions, ranging from favourable to marginal. In contrast to the crops discussed in other chapters in this book, maize is one of the world's most important internationally traded agricultural commodities. Maize is grown both by small-scale subsistence farmers (as is the case in many parts of Central and South America) and large-scale surplus-producing farmers (such as those in the US Midwest). Current projections in global cereal demand suggest that by 2020, demand for maize in developing countries will surpass that for wheat and rice, due largely to growth in demand for maize as livestock feed and also for ethanol (Rosegrant et al, 2006).

Maize holds particular importance in Mexico, both nutritionally and culturally. Mexico is a centre of origin and diversity for maize, and many Mexican indigenous groups believe that the maize plant represents the origin of life itself. The 2 million producers involved in maize production, together with their dependants, constitute around 8 per cent of the Mexican population (O'Brien, 1998, p92). Maize accounts for an average of 33.6 per cent of the calories and 30.3 per cent of the protein available to Mexican consumers (FAOSTAT, 2009), and the nutritional importance of this basic staple increases significantly for poor or rural populations. As Mexico has historically been the key source of

germplasm underpinning improvements in the crop worldwide, it is important to understand how Mexican farmers source and manage the seed of this important genetic resource.

Internationally, participation in the market for 'proprietary' (i.e. protected) maize seed by multinational companies is high. Some estimates suggest that the top three seed companies (Monsanto, Dupont and Syngenta) control as much as 65 per cent of this market (ETC Group, 2008). These trends are mirrored in Mexico, where there is a large market for 'formal-sector' maize seed (i.e. seed that has been produced under controlled conditions by plant breeders and has been certified through a national system of regulatory standards). The private sector plays an increasingly important role in the Mexican maize seed market, with the role of public agricultural research institutions declining, and barriers to seed imports lowered during the period of market liberalization in the 1990s. The maize seed market in Mexico is now characterized by significant competition between national seed companies and the local subsidiaries of major transnational companies. Nonetheless, on-farm seed-saving (i.e. the source of 'informal-sector' maize seed) remains the norm in many areas of the country.

The seed markets in La Frailesca in the state of Chiapas are interesting because, unlike other seed systems discussed in this book (and, indeed, even in other regions of Mexico), the formal seed sector plays a predominant role. Farmers' tendency to purchase improved seed has increased over time (see Bellon and Hellin, in preparation), and while an informal seed system functions in parallel with the formal system, the former consists primarily of farmer-to-farmer transactions mediated by purchase, barter, exchange and gifting. In other words, the archetypal 'rural market' discussed in other chapters of this book, in which farmers or farmer traders sell seed interchangeably with grain, is not characteristic of the situation in La Frailesca.

In this chapter, we explore the changes in farmers' sourcing of maize seed over the last several years, and discuss the implications for farmers' access to diversity in markets. We start by describing maize cultivation in Mexico, and include a discussion of the institutional context and a review of relevant literature addressing the implications of the shift from informal-sector to formal-sector seed sourcing for the *in situ* conservation of maize diversity. Following a discussion of the methodology, we then describe maize seed sourcing in La Frailesca, and changes in sourcing based on data from panel surveys carried out in 2004 and 2007. We supplement the information reported in the surveys with qualitative information that was collected in 2006 to 2007. We discuss farmers' maize-seed sourcing in La Frailesca in terms of the three dimensions of access considered in this book: availability of diversity; the cost/price of acquiring it; and the availability of associated information. Finally, we analyse the possible short- and long-term impacts of the formal seed sector upon local diversity.

Background: Study site and institutional context

Agricultural policies

Maize in Mexico is a widely consumed and multipurpose crop. White maize is primarily for direct human consumption, and yellow maize is predominantly a component of livestock feed (most in poultry, egg, and pork production) (Sain and López-Pereira, 1999). Approximately 12 million tonnes of white maize grain are consumed annually. Combine this amount with grain dedicated to livestock, industrial uses and national reserves, and the total yearly requirement for maize in Mexico is around 26 million tonnes. Approximately 20 million tonnes are produced nationally on 8 million hectares of agricultural land, most of it rain fed. Another 6 million to 7 million tonnes are imported, consisting mostly of yellow maize from the US (García Rañó and Keleman, 2007). Meanwhile, other maize products are used in both rural and urban areas across the country: maize stalks are used for fencing; husks are used for wrapping hot food and making crafts; and leaves are used as animal fodder.

Maize cultivation in Mexico is characterized by persistent disparities between small-scale and large-scale maize farmers in terms of their access to land, credit and other resources. For example, although recent statistics on the distribution of land among maize farmers are sparse,[1] estimates suggest that the Gini coefficient for land concentration is around 0.64 (Deininger and Olinto, 2000, cited in Puyana and Romero, 2006, p27). Inequality in land-tenure arrangements is reflected in recent statistics released by the Mexican Agricultural Secretary (SAGARPA) on the Programa de Apoyos Directos al Campo (PROCAMPO), the widest-reaching agricultural support programme in Mexico, which provides a per hectare subsidy for farmers planting maize and several other basic crops. In 2008, it was reported that farmers managing fewer than 5ha accounted for around 76 per cent of the total number of PROCAMPO recipients, but made up less than a third of the land area covered by the programme, and consequently received around one-third of the resources distributed. Meanwhile, the remaining 24 per cent of farmers planting areas greater than 5ha accounted for around two-thirds of the land supported by the programme and received a proportional amount of the resources distributed.

Mexican maize cultivation – including access to improved maize seed – has been heavily influenced by government support programmes over the last 30 to 40 years. Whereas the Mexican government provided significant support to farmers through the majority of the 20th century, this relationship was profoundly changed by the implementation of the North American Free Trade Agreement (NAFTA) in 1994. NAFTA opened the Mexican agricultural sector to 'free-market' imports from and exports to the US and Canada. The policy changes outlined in this agreement were accompanied by far-reaching reforms in the agricultural sector which affected the maize sector.

Prior to NAFTA, Mexico's maize sector was dominated by the Compañía Nacional de Subsistencias Populares (CONASUPO), the state-trading agency. In addition to influencing the prices at which maize was bought and sold, CONASUPO also had under its umbrella a series of associated businesses involved in maize marketing, storage and technology transfer. CONASUPO was dismantled at the end of the 1990s and, in the process, most of its sub-businesses were also eliminated (Yúnez-Naude, 2003). The elimination of CONASUPO was a key component of a series of sweeping changes to the agricultural sector made during economy-wide market liberalization, which aimed to reduce direct government intervention in agricultural markets. This period also saw the reorientation of resources away from maize cultivation towards areas where Mexico was thought to have a greater comparative advantage, such as fruit and horticulture.

There have been extensive reviews of the impacts of these policy changes upon Mexico's agricultural sector (e.g. Appendini, 2001; Yúnez-Naude, 2003; King, 2006; Puyana and Romero, 2006). However, specifically relevant to farmers acquiring maize seed is that these changes entailed the withdrawal of much government support for the development and transfer of agricultural technology, which had previously been provided through parastatal businesses. During the early 1990s, the national seed-producing programme Programa Nacional de Semillas (PRONASE), which had produced and sold seed to farmers at a subsidized price, was privatized. Meanwhile, restrictions on seed imports were lifted; federal investment in agricultural research decreased (see King, 2006); and the extension activities that had previously fallen under the responsibility of SAGARPA were eliminated. Some support was made available to maize farmers to help with this transition. The most important was the federally sponsored Kilo x Kilo programme, which initially encouraged farmers to exchange 1 kilo of their own maize seed for 1 kilo of improved seed. However, this was eventually converted to a more conventional seed subsidy. The Kilo x Kilo programme ended at the federal level in the early 2000s; but it was continued by some state governments, including that of Chiapas.

In summary, the Mexican maize seed sector has undergone significant changes during the past three decades, with government actions opening the way for private seed companies. These changes have gone hand in hand with broader changes in the agricultural economy.

Maize farmers in La Frailesca, Chiapas

La Frailesca includes the municipalities of Villaflores, Villacorzo, Angel Albino Corzo and La Concordia, together occupying an area of 2631 square kilometres, situated in the centre of the state of Chiapas (see Figure 8.1) (Erenstein et al, 1998). La Frailesca is situated in a valley at an altitude of 600m; but surrounding mountains have an elevation up to 2000m. Maize is the dominant crop in both

municipalities. Cattle-ranching is a complementary activity and maize crop residues are an important source of forage in the dry season.

Communities in La Frailesca have relatively good access to government-provided services and infrastructure. While the region produces large maize surpluses that are exported to other parts of Mexico, it is still dominated by small-scale farmers (Flores et al, 2004; Bellon et al, 2007). Farming activities in La Frailesca are both subsistence- and market-oriented, with 95.4 per cent of households reporting producing maize for both home consumption and market purposes, and 2.9 per cent reporting producing maize for home consumption exclusively. The region has received strong support from the state and federal governments, particularly for agricultural development.

The ethnic makeup is primarily *mestizo*, with 94.3 per cent of households speaking only Spanish, rather than an indigenous language (Bellon et al, 2007). The average agricultural landholdings in the study communities are around 5.3ha per household. Chemical fertilizers are used by 99.4 per cent of farmers, and some 60.5 per cent reported using hired labour in agricultural work. In 2001, approximately 14 per cent of households reported seasonal migration, and 13.6 per cent of households received remittances (Bellon et al, 2007).

It is difficult to compare La Frailesca households to the 'average' Mexican farm household due to a lack of updated national statistics. In general, however, farm households in La Frailesca are more market-oriented and more inclined to use commercially available agricultural technology than many of their counterparts.[2] Nonetheless, despite these relative advantages, some 48.9 per cent of the population in La Frailesca are in 'extreme poverty' (CONEVAL, 2009).

Improved germplasm has been available in La Frailesca for over 20 years. Many farmers date their first use of improved maize seed to the 1980s, when government programmes distributed open-pollinated variety (OPV) seed as part of technical assistance packages. In focus group discussions carried out between 2005 and 2007, farmers consistently remembered that the most marked displacement of landrace varieties took place during this period. By the mid-1990s, these farmers were already accustomed to relying on OPVs rather than landraces. These OPVs were reproduced through traditional seed-saving practices.

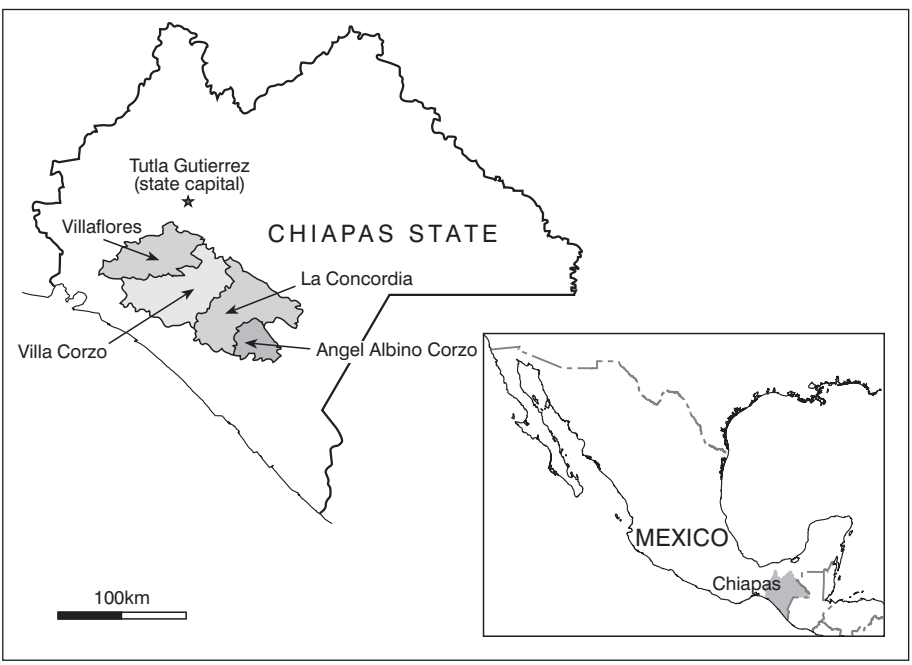
Hybrid varieties, in contrast, have been available to small-scale farmers in La Frailesca for a little more than a decade. Some farmers dated their first use of hybrid maize to the late 1990s, relating their adoption to seed companies' practices of gifting a small amount of seed for farmers to experiment with. Other farmers have been able to access hybrid seed through government-sponsored programmes, including a seed subsidy that covered a large proportion of the cost of hybrid seed.

The co-existence of formal and informal seed systems in La Frailesca is largely due to the implementation of agricultural policies designed to promote maize productivity in one of the key 'bread baskets' of Mexico. Chiapas is the fourth-highest maize-producing state in the country, with La Frailesca making

up a significant proportion of this production. Much of what is produced in Chiapas is exported to nearby states. Hence, while Mexico's agricultural development strategy in recent decades has largely been built around divestment from maize agriculture, state support for maize in La Frailesca has remained comparatively strong. Government investments have been targeted at increasing maize yields by encouraging small-, medium- and large-scale farmers to use improved seed and other inputs such as fertilizer.

METHODOLOGY

The International Maize and Wheat Improvement Centre (CIMMYT) has conducted research on farmers' management of maize and broader livelihood issues intermittently in La Frailesca since the late 1980s (Hibon et al, 1989; Erenstein et al, 1998). The primary source of the analysis presented in this chapter is quantitative and qualitative research conducted between 2004 and 2007 in four communities: Dolores Jaltenango, Roblada Grande, Libertad Melchor Ocampo and Querétaro (see Figure 8.1). Panel surveys were undertaken in these communities in 2004, and 2007,[3] and qualitative methods were used to explore contextual issues in 2005 to 2007.



Source: V. Hernández, CIMMYT

Figure 8.1 *Map of Chiapas showing the municipalities in La Frailesca where research was carried out*

In La Frailesca, communities of between 1000 and 2500 inhabitants were targeted. The upper limit of 2500 inhabitants is the parameter used in Mexico to define rural populations. The lower bound was chosen to capture a sufficient amount of intra-location variability in socio-economic conditions. The selection of the four communities was based on a marginality index developed by Mexico's National Population Board (Consejo Nacional de Población, or CONAPO) and the Education, Health and Food Programme (Programa de Educación, Salud y Alimentación, or PROGRESA) (CONAPO-PROGRESA, 2000). Although widely used by the Mexican government to target poverty reduction programmes, this index does not measure poverty *per se*, but marginality as a proxy for poverty (i.e. the lack of access to essential goods and services). According to this index, locations in Mexico may be classified into five marginality levels: very low; low; intermediate; high; and very high. The index has the advantage of being available in disaggregated form, by location, for most of Mexico. The four villages chosen are representative of the poverty levels found in La Frailesca and represented marginality levels from medium to very high (Bellon et al, 2007).

The 2004 and 2007 surveys were undertaken with 120 farmers, broken down to include a sample of 30 farmers per village. In 2007, and when a previously surveyed farmer was not available, another farmer from the same village was chosen to take his or her place. This generated a panel of 109 farmers who were present for both surveys.[4] During the surveys, particular attention was devoted to the maize varieties planted, the reasons why farmers planted different maize varieties, and the origin and history of management of the seed planted. Maize classification was based on a typology developed by Bellon et al (2007) in which there are five categories:

1 commercial hybrids;
2 recycled hybrids (seed of hybrid seed that has been replanted from one to four times);
3 improved open-pollinated varieties (OPVs);
4 creolized varieties (seed from improved varieties – hybrids or OPVs – that have been recycled for four or more years); and
5 landraces or local varieties (see Table 8.1).

Qualitative research relied primarily on focus group discussions and semi-structured interviews, complemented with participant observation. CIMMYT had previously conducted research in La Frailesca on seed input chains and had compiled a list of companies and producer groups engaged in marketing maize seed. CIMMYT used this list as the basis for identifying current actors in the maize input and output chains. A market-mapping tool based on Hellin et al (2005) was used to identify further different players in the input and output chains. Research focused on key informants along the maize seed input and

Table 8.1 *A typology of maize*

Category	*Criteria*
Hybrid	• Name provided by farmer is of a known hybrid • Seed 'came from a bag' for the first year planted • Focus group identified name as introduced to the community by government or commercial outlet • Maize taxonomist indicated sample with same name was of a hybrid or a recycled hybrid
Recycled hybrid	• Same as above, but farmer planted seed from previous harvest up to four years
Open-pollinated variety (OPV)	• Same as above, but name provided by farmer is of a known OPV • Seed planted for the first time or recycled up to four years
Creolized variety	• Any of the above, but farmer recycled seed for more than 4 years and up to 15 years
Landrace (criollo)	• Name provided by farmer is of a known maize race (e.g. *Zapalote*, *Tepecente*, *Olotillo*) • No specific name (*maíz blanco*), but planted for many years by either the surveyed farmer or someone else in the community • Did not 'come from a bag' • Focus group identified name as that of a local variety • Taxonomist indicated sample of the same name was a landrace

Source: Bellon et al (2007)

grain output chains: seed companies, extension agents, producer groups and purchasers of grain.

Interviews were also undertaken with officials at both the state and local levels and included representatives from the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA); the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP); and the Secretaría del Campo (formerly the Secretaría de Desarrollo Rural) (SDR). These interviews focused on comparing field observations about the implementation of agricultural and non-agricultural policies with the formal design and administration of government programmes.

In order to gather information from farmers in the four communities, focus group meetings in 2005 and 2006 were of mixed genders: focus groups in 2007 were undertaken separately with men (in all four communities) and women (in three of the four communities). Focus groups with both sexes discussed types of maize being grown and their agronomic benefits/drawbacks, as well as migration. Focus groups with men also addressed government programmes and subsidies, and the availability of agricultural credit and technical assistance. Focus groups with women discussed maize culinary qualities and family preferences for particular types of maize, and the impacts of a government programme called Oportunidades.

In addition, we estimated local diversity in formal- and informal-sector germplasm by characterizing 30 locally collected seed lots that included traditional landraces, creolized varieties and commercially sold hybrid and OPV varieties for agronomic traits and molecular markers. Diversity estimates were adjusted for local abundance to provide a fair comparison of accessible diversity in different types of seed. Details are provided in van Heerwaarden et al (2009). We addressed the extent to which local varieties are genetically connected to commercial varieties through pollen flow by generating model-based estimates of cross-pollination. We obtained information on identity and flowering dates of all planted maize varieties and used published data on the temporal (Uribelarrea et al, 2002) and spatial (Ma et al, 2004) pollen dynamics to simulate pollen flow into farmers' fields where landraces are cultivated.

Access to crop genetic diversity in markets: Empirical evidence

In this section, we use data from the 2004 and 2007 surveys, coupled with observations from qualitative research, to describe trends in farmers' access to diversity in La Frailesca seed markets, characterizing access in terms of availability, price and information.

Availability of diversity

Improved maize seed is sold primarily through official distributors, the vast majority of whom have outlets in the town of Villaflores, the major town in La Frailesca (see Table 8.2). However, these distributors were too few in number for it to be possible to generate a dataset suitable for econometric analysis by surveying them; furthermore, this would have provided an incomplete picture of the diversity available in the region since a large proportion of farmers' seed continues to originate from informal sources. Hence, here we rely on measures of farmers' use of diversity on farm and the sources from which farmers reported acquiring seed as a proxy for the 'availability' of diversity in the region.

Previously collected data demonstrated a significant increase in the use of hybrid seed in the selected four villages between 2001 and 2004, and a concomitant decrease in the use of landraces. The area planted in hybrid maize increased from 115.7ha to 222.5ha during this period, with the number of farmers reporting planting hybrid maize increasing from 45 to 67 (N = 89). Meanwhile, the average area per farmer planted to landraces decreased from 2.29ha to 0.91ha and the number of farmers planting them dropped off from 52 to 42 (N = 89) (Bellon and Hellin, in preparation). Follow-up qualitative research exploring this trend suggested that as farmers have become more fully integrated within formal seed markets, they have become less concerned about the non-yield attributes of a maize variety (e.g. culinary attributes) and place more emphasis on

Table 8.2 *Seed companies operating in La Frailesca region, Chiapas (2004)*

Seed brand	*Company*	*Type of company*	*Type of germplasm sold*
Asgrow	A brand of Semillas y Agroproductos Monsanto SA de CV	Semillas y Agroproductos Monsanto SA de CV is a subsidiary of Monsanto Company; global transnational company	Hybrids
Hartz Seed	A brand of Semillas y Agroproductos Monsanto SA de CV	Semillas y Agroproductos Monsanto SA de CV is a subsidiary of Monsanto Company; global transnational company	Hybrids
Pioneer	PHI Mexico SA de CV	Subsidiary of Pioneer Hi-Bred International, Inc; global transnational company	Hybrids
Novasem	Hibridos Novasem S.A. de CV	Mexican seed company	Hybrids
Cristiani-Burkard	Semillas Cristiani Burkard, SA de CV	Regional company operating in Mexico and Central America	Hybrids
CERES	Ceres Internacional de Semillas SA de CV	Regional company operating in Mexico, Central America	hybrids
PROASE	Productores Asociados de Semillas, SC de RL de CV	Mexican seed company	Hybrids and open-pollinated varieties (OPVs)
Productores de Semillas de San Pedro Buenavista		Local farmer co-operative	OPVs

Source: adapted from Flores et al (2004)

varieties that generate the highest yield and therefore the greatest cash reward (Keleman et al, 2009).

A comparison of data collected in 2004 and 2007 show slight changes in this trend. From 2004 to 2006, the total area in maize decreased from 526ha to 406ha (a reduction of 23 per cent) (see Table 8.3). The decrease in area planted was particularly dramatic for hybrids and OPVs (i.e. purchased seed), but was minimal for creolized varieties and landraces. In the case of recycled hybrids, there was an increase in area planted. When germplasm use is assessed in terms of number of farmers (see Table 8.3), there was a slight increase in the number of farmers planting creolized varieties and landraces between 2004 and 2006 (from 26 to 28 per cent of the panel). In other words, these data show that despite the sharp increase in the use of formally sourced seed observed between 2001 and 2004, formal and informal systems continue to coexist, and informal seed systems have maintained their importance in more recent years. These patterns are consistent with qualitative information that points out that growing

Table 8.3 *Changes in areas planted with different maize varieties and number of farmers planting (2004–2006)*

Year	*Hybrids*	*Recycled hybrids*	*Open-pollinated variety (OPV)*	*Creolized varieties*	*Landraces*	*Total*
A Total area (ha)						
2004	281.05	23.25	63.25	70.3	88.25	526.1
2006	220.9	27.3	11.85	69.2	76.375	405.625
Difference	–60.15	4.05	–51.4	–1.1	–11.875	–120.475
Difference (%)	–21	17	–81	–0.02	–0.13	–23
B Percentage of total farmers planting this type of germplasm (N = 109)						
2004	69.72	11.01	30.28	25.69	41.28	
2006	61.47	11.01	9.17	28.44	44.04	
Difference	–8.26	0.00	–21.10	2.75	2.75	
C Average area per farmer (ha) (total panel)						
2004	2.58	0.21	0.58	0.64	0.81	4.83
2006	2.03	0.25	0.11	0.63	0.70	3.72
Difference of means	–0.55	0.04	–0.47	–0.01	–0.11	–1.11
P-value difference	0.1	ns	0.0000	ns	ns	0.005

Note: ns = not significant.
Source: authors' calculation using 2004 and 2007 project survey data

maize is becoming less profitable, but landraces and creolized varieties are still an important component of livelihood strategies as the basis for food consumption and security.

Another measurement of these trends is offered by the number of seed lots (i.e. individual germplasm types) farmers reported planting (see Table 8.4). This measurement reflects the trends discussed above, with hybrids emerging as the most important category of seed in both time periods (46.1 per cent of seed lots in 2004 and 41.1 per cent in 2006). Landraces, creolized and OPVs are of about equal importance in 2004 (representing 14 to 18 per cent of seed lots); but in 2006 this had changed, with the importance of OPVs dropping off drastically (to 4.7 per cent) and the proportion of landraces increasing (to 28.5 per cent). The proportion of creolized seed lots increased slightly (17.3 per cent), as did the proportion of the least important category: recycled hybrids (5.4 to 8.4 per cent).

These trends in the use of different germplasm types were mirrored within the four survey villages during this time period (see Tables 8.5a to 8.5d), with landrace seed-lots increasing, OPVs dropping off drastically, and hybrids dropping off somewhat as a proportion of all seed-lots.

However, these trends were more marked in some places than others. For example, the increase in landrace use was less marked in Dolores Jaltenango (just a 3 per cent increase), whereas the use of hybrids as a percentage of total seed lots in

Table 8.4 *Source of seed lots (purchased and off-farm acquisitions) (2004 and 2006)*

	N	*Own-saved Percentage of germplasm type acquired from source*	*N*	*Gift Percentage of germplasm type acquired from source*	*N*	*Purchased Percentage of germplasm type acquired from source*	*N*	*Other* Percentage of germplasm type acquired from source*	*N*	*Totals Percentage of total seed lots in this germplasm type*
Germplasm type 2004										
Criollo	39	90.7	1	2.3	1	2.3	2	4.7	43	16.7
Creolized	31	86.1	0	0.0	5	13.9	0	0.0	36	14.0
Open-pollinated variety (OPV)	17	37.0	1	2.2	28	60.9	0	0.0	46	17.8
Recycled hybrid	11	78.6	0	0.0	3	21.4	0	0.0	14	5.4
Hybrid	0	0.0	2	1.7	114	95.8	3	2.5	119	46.1
Total	98	38.0	4	1.6	151	58.5	5	1.9	258	
Germplasm type 2006										
Criollo	45	73.8	4	6.6	12	19.7	0	0.0	61	28.5
Creolized	36	97.3	1	2.7	0	0.0	0	0.0	37	17.3
OPV	1	10.0	3	30.0	6	60.0	0	0.0	10	4.7
Recycled hybrid	10	55.6	1	5.6	7	38.9	0	0.0	18	8.4
Hybrid	1	1.1	0	0.0	83	94.3	4	4.5	88	41.1
Total	93	43.5	9	4.2	108	50.5	4	1.9	214	

Proportional change, 2004–2006	*Change in proportion of seed lots acquired from each source*				*Change in proportion of seed lots represented by germplasm type*
Criollo	–16.9%	4.2%	17.3%	–4.7%	11.8%
Creolized	11.2%	2.7%	–13.9%	n/a	3.3%
OPV	–27.0%	27.8%	–0.9%	n/a	–13.2%
Recycled hybrid	–23.0%	5.6%	17.5%	n/a	3.0%
Hybrid	1.1%	n/a	–1.5%	2.0%	–5.0%
Total	5.5%	2.7%	–8.1%	–0.1%	

Notes: * 'Other' includes seeds reported as exchanged, bartered or loaned.
n/a = not available.
Source: authors' calculation using 2004 and 2007 project survey data

Table 8.5 *Source of seed lots (purchased and off-farm acquisitions) by village (2004 and 2006)*

	N	*Own-saved Percentage of germplasm type acquired from source*	*N*	*Gift Percentage of germplasm type acquired from source*	*N*	*Purchased Percentage of germplasm type acquired from source*	*N*	*Other* Percentage of germplasm type acquired from source*	*N*	*Totals Percentage of total seed lots in this germplasm type*
(a) Melchor Ocampo										
Germplasm type 2004										
Criollo	4	100.0	0	0.0	0	0.0	0	0.0	4	7.3
Creolized	5	83.3	0	0.0	1	16.7	0	0.0	6	10.9
OPV	6	50.0	1	8.3	5	41.7	0	0.0	12	21.8
Recycled hybrid	2	66.7	0	0.0	1	33.3	0	0.0	3	5.5
Hybrid	0	0.0	1	3.3	28	93.3	1	3.3	30	54.5
Total	17	30.9	2	3.6	35	63.6	1	1.8	55	
Germplasm type 2006										
Criollo	6	85.7	0	0.0	1	14.3	0	0.0	7	14.6
Creolized	3	100.0	0	0.0	0	0.0	0	0.0	3	6.3
OPV	1	33.3	2	66.7	0	0.0	0	0.0	3	6.3
Recycled hybrid	7	63.6	1	9.1	3	27.3	0	0.0	11	22.9
Hybrid	0	0.0	0	0.0	20	83.3	4	16.7	24	50.0
Total	17	35.4	3	6.3	24	50.0	4	8.3	48	
Change in proportion 2004–2006										
Criollo		-14.3		n/a		14.3		n/a		7.3
Creolized		16.7		n/a		–16.7		n/a		–4.7
OPV		-16.7		58.3		–41.7		n/a		–15.6
Recycled hybrid		–3.0		9.1		–6.1		n/a		17.5
Hybrid		n/a		–3.3		–10.0		13.3		–4.5
Total		4.5		2.6		–13.6		6.5%		

Notes: * 'Other' includes seeds reported as exchanged, bartered or loaned.
n/a = not available.

Table 8.5 *continued*

	N	*Own-saved Percentage of germplasm type acquired from source*	*N*	*Gift Percentage of germplasm type acquired from source*	*N*	*Purchased Percentage of germplasm type acquired from source*	*N*	*Totals Percentage of total seed lots in this germplasm type*
(b) Roblada Grande								
Germplasm type 2004								
Criollo	10	100.0	0	0.0	0	0.0	10	13.5
Creolized	18	85.7	0	0.0	3	14.3	21	28.4
OPV	1	33.3	0	0.0	2	66.7	3	4.1
Recycled hybrid	5	83.3	0	0.0	1	16.7	6	8.1
Hybrid	0	0.0	0	0.0	34	100.0	34	45.9
Total	34	45.9	0	0.0	40	54.1	74	
Germplasm type 2006								
Criollo	12	85.7	1	7.1	1	7.1	14	23.3
Creolized	18	100.0	0	0.0	0	0.0	18	30.0
OPV	0	0.0	0	0.0	0	0.0		0.0
Recycled hybrid	0	0.0	0	0.0	1	100.0	1	1.7
Hybrid	0	0.0	0	0.0	27	100.0	27	45.0
Total	30	50.0	1	1.7	29	48.3	60	
Change in proportion 2004–2006								
Criollo		–14.3		7.1		7.1		9.8
Creolized		14.3		n/a		–14.3		1.6
OPV		–33.3		n/a		–66.7		–4.1
Recycled hybrid		–83.3		n/a		83.3		–6.4
Hybrid		n/a		n/a		n/a		–0.9
Total		4.1		1.7		–5.7		

Note: * The 'other' category was eliminated here because no seed lots were reported as traded, bartered or loaned in Roblada Grande in this time period.

Table 8.5 *continued*

	N	*Own-saved Percentage of germplasm type acquired from source*	N	*Gift Percentage of germplasm type acquired from source*	N	*Purchased Percentage of germplasm type acquired from source*	N	*Other* Percentage of germplasm type acquired from source*	N	*Totals Percentage of total seed lots in this germplasm type*
(c) Dolores Jaltenango										
Germplasm type 2004										
Criollo	17	81.0	1	4.8	1	4.8	2	9.5	21	30.9
Creolized	4	80.0	0	0.0	1	20.0	0	0.0	5	7.4
OPV	2	20.0	0	0.0	8	80.0	0	0.0	10	14.7
Recycled hybrid	2	100.0	0	0.0	0	0.0	0	0.0	2	2.9
Hybrid	0	0.0	0	0.0	28	93.3	2	6.7	30	44.1
Total	25	36.8	1	1.5	38	55.9	4	5.9	68	
Germplasm type 2006										
Criollo	12	63.2	1	5.3	6	31.6	0	0.0	19	33.3
Creolized	6	100.0	0	0.0	0	0.0	0	0.0	6	10.5
OPV	0	0.0	1	100.0	0	0.0	0	0.0	1	1.8
Recycled hybrid	1	50.0	0	0.0	1	50.0	0	0.0	2	3.5
Hybrid	0	0.0	0	0.0	29	100.0	0	0.0	29	50.9
Total	19	33.3	2	3.5	36	63.2	0	0	57	
Change in proportion 2004–2006										
Criollo		–17.8		0.5		26.8		–9.5		2.5
Creolized		20.0		n/a		–20.0		n/a		3.2
OPV		–20.0		100.0		–80.0		n/a		–13.0
Recycled hybrid		–50.0		n/a		50.0		n/a		0.6
Hybrid		n/a		n/a		6.7		–6.7		6.8
Total		–3.4		2.0		7.3		–5.9		

Notes: * 'Other' includes seeds reported as exchanged, bartered or loaned.
n/a = not available.

Table 8.5 *continued*

	N	*Own-saved Percentage of germplasm type acquired from source*	*N*	*Gift Percentage of germplasm type acquired from source*	*N*	*Purchased Percentage of germplasm type acquired from source*	*N*	*Totals Percentage of total seed lots in this germplasm type*
(d) Querétaro								
Germplasm type 2004								
Criollo	8	100.0	0	0.0	0	0.0	8	13.1
Creolized	4	100.0	0	0.0	0	0.0	4	6.6
OPV	8	38.1	0	0.0	13	61.9	21	34.4
Recycled hybrid	2	66.7	0	0.0	1	33.3	3	4.9
Hybrid	0	0.0	1	4.0	24	96.0	25	41.0
Total	22	36.1	1	1.6	38	62.3	61	
Germplasm type 2006								
Criollo	15	71.4	2	9.5	4	19.0	21	42.9
Creolized	9	90.0	1	10.0			10	20.4
OPV	0	0.0	0	0.0	6	100.0	6	12.2
Recycled hybrid	2	50.0	0	0.0	2	50.0	4	8.2
Hybrid	1	12.5	0	0.0	7	87.5	8	16.3
Total	27	55.1	3	6.1	19	38.8	49	
Change in proportion 2004–2006								
Criollo		–28.6		9.5		19.0		29.7
Creolized		–10.0		10.0		n/a		13.9
OPV		–38.1		n/a		38.1		–22.2
Recycled hybrid		–16.7		n/a		16.7		3.2
Hybrid		12.5		–4.0		–8.5		–24.7
Total		19.0		4.5		–23.5		

Notes: * The 'other' category was eliminated here because no seed lots were reported as traded, bartered or loaned in Querétaro in this time period.
n/a = not available.
Source: authors' calculation using 2004 and 2007 project survey data

this village actually *increased* during this period (44 to 51 per cent), contrary to the trend for the other villages. Meanwhile, at the other extreme, Querétaro showed the biggest proportional increase in landrace seed lots of the four villages during this period (13 to 43 per cent) and the largest drop-off in the use of hybrids (41 to 16 per cent). The fact that opposite trends were observed in these two villages in particular is noteworthy given that these villages are similar in having higher levels of poverty and marginality than the other two villages where the surveys were carried out; and being more remote from major urban centres (with Querétaro being the extreme case in this regard). This would rule out any hypothesis of a simplistic, unidirectional relationship between trends in the use of a specific germplasm type and village-level measures of remoteness or marginality.

In terms of seed sourcing, the most frequent source of seed for farmers was purchase in both 2004 and 2006, although the percentage of seed lots purchased decreased by 8 per cent (see Table 8.4). This decrease was compensated by a 5 per cent increase in the number of seed lots saved and a slight increase in gifted seed.

Seed sourcing varied by germplasm type. For landraces, the most common form of acquisition in both survey years was on-farm seed saving; but this decreased in importance between 2004 and 2006, with 17 per cent fewer landrace seed lots in 2006 farm saved (see Table 8.4). The proportions that were gifted and purchased increased (4.2 and 17.3 per cent, respectively; see Table 8.4). Similar patterns were apparent for OPV and recycled hybrid seed, for which on-farm seed-saving decreased (down 27 and 23 per cent, respectively), with reports of gifted and purchased seed lots increasing. However, for creolized seed, the most important source continued to be on-farm seed saving, increasing by 11.2 per cent over the period of 2004 to 2006. This mostly off-set the proportion of seed that was purchased and which dropped by 13.9 per cent. Meanwhile, the proportion of hybrid seed sourced by purchasing decreased slightly during this time period; but purchased seed still accounted for 94.3 per cent of hybrid seed lots reported in 2006.

Trends in seed sourcing were generally the same within individual communities as in the aggregated dataset, with a few notable exceptions (see Table 8.5). For example, in Querétaro, there was a slight decrease in seed saving for creolized seed, contrary to the aggregate trend. For hybrids, the trend was the same in Melchor Ocampo and Querétaro as in aggregate; but the percentage of purchased seed-lots stayed level in Roblada Grande, and actually increased in Dolores Jaltenango.

Table 8.6 describes the sub-set of seed lots that were sourced off farm, including seed sourced from informal sources (i.e. social connections), 'political sources' (i.e. gifts by political candidates) or formal sources (i.e. sellers of seed in the formal seed sector). Overall, informal sources maintained about the same level of importance between 2004 (15.9 per cent) and 2006 (16.7 per cent). Political sources dropped off in importance (33.1 to 6.7 per cent), and formal purchased sources increased in importance (51.0 to 76.7 per cent).[5]

Table 8.6 *Off-farm sourced seed lots by source type (2004 and 2006)*

	*Non-purchased (informal) source**		*Political source***		*Formal source****		*Total*
	N	*Percentage of seed lots from source*	*N*	*Percentage of seed lots from source*	*N*	*Percentage of seed lots from source*	
2004							
Criollo	4	80.0	1	20.0	0	0.0	5
Creolized	4	80.0	0	0.0	1	20.0	5
OPV	3	10.7	18	64.3	7	25.0	28
Recycled hybrid	1	50.0	0	0.0	1	50.0	2
Hybrid	13	11.1	33	28.2	71	60.7	117
Total	25	15.9	52	33.1	80	51.0	157
2006							
Criollo	11	73.3	1	6.7	3	20.0	15
Creolized	1	100.0	0	0.0	0	0.0	1
OPV	4	44.4	3	33.3	2	22.2	9
Recycled hybrid	3	37.5	0	0.0	5	62.5	8
Hybrid	1	1.1	4	4.6	82	94.3	87
Total	20	16.7	8	6.7	92	76.7	120

Notes: * 'Informal' sources include *compadres*, friends, neighbours, family and strangers.
** 'Political' sources include candidates for office, agricultural/political organizations and parties, and the municipal government.
*** 'Formal' sources include veterinary shops, *despachos* and seed distributors.
Source: authors' calculation using 2004 and 2007 project survey data

In terms of the relationship between choice of source and germplasm type, informal non-purchased sources are the biggest source of landrace and creolized seed in both 2004 and 2006 (see Table 8.6). Political candidates were the most important source of OPV seed in 2004 (64.3 per cent; 18 seed lots); but this dropped off drastically in 2006 (33.3 per cent; only three seed lots). Informal-source seed made up the difference, with the percentage of formally purchased OPV seed remaining approximately equal. The change in importance of political candidates as a source of OPV seed was almost certainly linked to the election cycle and candidates' political strategies to win more rural votes, and as such is likely non-random.

For recycled hybrids, which represented a small percentage of seed lots, there was an even split between informal and formally purchased seed sourcing in 2004. In 2006, the use of recycled hybrids had increased, with a higher percentage of farmers reporting having purchased them from a formal source. For hybrids, the most important source was formal purchase, with this increasing from 60.7 per cent in 2004 to 94.3 per cent in 2006. The importance of informal sourcing for hybrids dropped off a great deal (11.1 to 1.1 per cent), as did the importance of political sources (33.1 to 6.7 per cent).

The existence of a state-sponsored seed subsidy in La Frailesca during this period sheds light on the trends in seed-sourcing for improved (and particularly hybrid) germplasm. This subsidy began in 2002 when the federal Kilo x Kilo programme ended. In 2005, the SDR subsidized 33,000 bags of seed, benefiting 16,000 producers. In 2006, the subsidy reached slightly fewer farmers, covering 29,000 bags destined for 15,500 individuals, although there was demand throughout La Frailesca for as much as 36,000 bags. While there was some variation from year to year, in 2006 the subsidy amounted to 300 pesos[6] per bag of seed with a limit of two bags per farmer (i.e. 600 pesos per farmer). Each bag contains enough seed to plant 1ha, and farmers themselves paid the difference between the cost of the seed and the subsidy.

The seed subsidy was used to acquire either OPVs or hybrids from the formal seed sector. In 2006, the SDR estimated that about 70 per cent of the subsidy was used to purchase hybrids, and 30 per cent was devoted to OPVs. In 2006, the amount distributed was equivalent to about 30 per cent of the total area planted to maize in La Frailesca in the spring–summer cycle. As discussed below, the presence of this subsidy played a major role in mediating farmers' access to seed and helps to explain the increasing importance of formal-sector purchase of hybrid seed in La Frailesca.

Meanwhile, the parallel trend towards increased seed saving and slightly higher levels of landrace use between 2004 and 2006 may be a reflection of wider economic conditions. Despite government investment in increasing maize production via the seed subsidy, international maize prices were falling during the period in question, and farmers reported that maize production was becoming a less profitable activity. This is reflected in the overall decrease in area planted to maize in the region (see Table 8.3). However, the increase in use of creolized and landrace seed may be a testament to the fact that production in this area is both commercial and subsistence-oriented, and farmers make investment decisions in their crops based on their expectations of profitability. In other words, while the decrease in area planted to maize may represent farmers' reducing the time and money that they invest in this crop in the face of low profitability, the relatively robust persistence of landraces may reflect farmers' decision to keep some percentage of their land in subsistence maize production for household use, which they plant with low-cost farm-saved seed, or seed that is otherwise locally available through social networks.

Prices and other acquisition costs

One of the key elements determining farmers' access to seed is price. Table 8.7 summarizes prices paid per bag as reported by farmers in 2004 and 2006. Price trends for landraces, creolized varieties and recycled hybrids are difficult to analyse across years because the sample size of farmers reporting purchasing these varieties was very small. Notably, however, the mean price that farmers reported paying for landrace seed in 2006 (40 pesos per bag) was significantly

Table 8.7 *Prices per bag by seed type (2004 and 2006)*

	2004					2006				Percentage change 2004–2006	
	N	*Mean*	*Median*	*Minimum*	*Maximum*	*N*	*Mean*	*Median*	*Minimum*	*Maximum*	*Mean*	*Median*
Melchor Ocampo												
OPV	5	179	120	55	350							
Hybrid	27	697	730	20	850	19	592	580	85	940	–15.1	–20.5
Roblada Grande												
Landrace						1	20	20	20	20		
Creolized	2	430	430	100	760							
OPV	2	255	255	150	360							
Recycled hybrid	1	790	790	790	790							
Hybrid	31	682	760	50	850	27	601	560	250	960	–11.9	–26.3
Dolores Jaltenango												
Landrace						3	47	60	20	60		
OPV	8	123	95	80	250							
Recycled hybrid						1	410	410	410	410		
Hybrid	28	661	700	60	780	29	508	500	110	850	–23.1	–28.6
Querétaro												
OPV	13	96	100	50	120	4	388	350	250	600	303.0	250.0
Hybrid	24	208	200	60	700	7	379	300	200	750	82.1	50.0
Total												
Landrace						4	40	40	20	60		
Creolized	2	430	430	100	760							
OPV	28	130	100	50	360	4	388	350	250	600	198.5	250.0
Recycled hybrid	1	790	790	790	790	1	410	410	410	410	–48.1	–48.1
Hybrid	110	577	700	20	850	82	547	550	85	960	–5.2	–21.4

Source: authors' calculation using 2004 and 2007 project survey data

lower than the prices paid for other seed types, representing approximately 10 per cent of the prices paid for recycled hybrids and OPVs, and 7 per cent of the price paid for hybrids.

Trends in prices for improved germplasm varied for hybrids, recycled hybrids and OPVs. While the trend for OPVs was a price increase, the trend in prices reported for recycled hybrids and hybrids was actually negative, with farmers paying less in 2006 than they did in 2004 (the exception to this trend at the village level was Querétaro, where farmers reported paying more for hybrids in 2006 than 2004). On average, the range of prices paid by farmers narrowed with the minimum price reported increasing a great deal, while the maximum increased only slightly.

This trend in average hybrid prices may imply that the seed subsidy was being applied more evenly across the study group in 2006 than in 2004, decreasing the range of variation in the prices that farmers paid. The opposite trend in Querétaro might reflect uneven application of the subsidy or a negative experience with hybrid seed there.

The reasons that farmers reported for choosing specific seed sources are shown in Table 8.8. Seed lots for which the source was chosen because it was the 'only known source' increased significantly between 2004 and 2006, especially for formal seed (OPVs, recycled hybrids and hybrids). This is particularly the case for hybrid seed where 'only known source' was the reason for choosing the source for 75.9 per cent of seed lots (63 of 83 seed lots; see Table 8.8). The importance that farmers gave to price and ease of obtaining seed dropped off for both OPVs and hybrids between 2004 and 2006, although more farmers named these as being important for recycled hybrids than in 2004. Creolized seed was not widely sourced off-farm; but notably no one named off-farm sourcing as being the 'only source' in 2006, whereas the only seed lot sourced off-farm in 2004 was justified for this reason.

Notably, credit was only identified as being offered in 2004. Percentage wise, it was more important for recycled hybrids and creolized seed; but in terms of absolute numbers, it was reported for more hybrid seed lots than other types (see Table 8.8).

Table 8.9 summarizes farmers' reported reasons for choosing a source of seed (for purchased seed lots only). The number of farmers reporting a formally purchased source as 'only known source' increased a great deal from 2004 (32.5 per cent) to 2006 (77.6 per cent). This trend (towards 'only known source') was also true for seed lots in aggregate (21.4 per cent in 2004 to 68.3 per cent in 2006). The importance of all other reasons given across years decreased in aggregate.

Sourcing via a political source was identified as cheapest (58 per cent of seed lots; 29 out of 50 seed lots) or easiest (22 per cent of seed lots; 11 out of 50 seed lots) for the majority of seed lots acquired through this category in 2004. However, neither of these reasons was cited for political sourcing in 2006 (and,

Table 8.8 *Reasons for choosing a seed source by germplasm type (includes seed lots reported as purchased only)*

	Only known source for variety	*Cheapest source*	*Easiest source for obtaining seed or variety*	*Most trusted source*	*To try it out*	*Only mentioned in 2004 Previously used source (known)*	*Recommended source*	*Credit offered*	*Gifted*	*Total*	*Percentage of total purchased seed lots represented by germplasm type*
2004											
Landrace	1	0	0	0	0	0	0	0	0	1	0.7
Creolized	1	0	1	1	0	0	0	1	0	4	2.7
OPV	1	17	8	0	0	1	0	0	0	27	18.5
Recycled hybrid	0	0	0	0	1	0	0	1	0	2	1.4
Hybrid	28	22	34	12	3	3	3	10	1	112	76.7
Total	31	39	43	13	4	4	3	12	1	146	100.0
Percentage of total seed lots	*21.2*	*26.7*	*29.5*	*8.9*	*2.7*	*2.7*	*2.1*	*8.2*	*0.7*		
2006											
Landrace	0	7	1	1	0					9	8.7
Creolized	0	0	0	0	0					0	0.0
OPV	4	2	1	0	0					6	5.8
Recycled hybrid	4	1	2	0	0					6	5.8
Hybrid	63	10	8	3	2					83	79.8
Total	71	20	12	4	2					104	100.0
Percentage of total seed lots	*68.3*	*19.2*	*11.5*	*3.8*	*1.9*						

Note: More than one response per seed lot is possible; some farmers (five) for which no information was provided have been eliminated.
Source: authors' calculation using 2004 and 2007 project survey data

Table 8.9 *Reasons for choosing a seed source by source (includes seed lots reported as purchased only)*

	Reported 2004 and 2006				*Only reported in 2004*						
	Only known source with desired variety	*Cheapest source*	*Easiest source*	*Most trusted source*	*To try it out*	*Previously used source (known)*	*Recommended source*	*Credit offered*	*Gifted*	*Total*	*Percentage of total seed lots purchased from source*
2004											
Informal source*	5	0	8	2	1	0	1	2	0	18	
Political source**	1	29	11	1	1	0	1	2	0	50	34.5
Formally purchased source***	25	9	26	8	2	1	2	8	1	77	53.1
Total	31	38	45	11	4	1	4	12	1	145	
Percentage of total seed lots purchased for this reason	*21.4*	*26.2*	*31.0*	*7.6*	*3.8*	*0.7*	*2.8*	*8.3*	*0.7*		
2006											
Informal source*	1	9	4	1	0					14	13.5
Political source**	4	0	0	0	1					5	4.8
Formally purchased source**	66	11	8	3	1					85	81.7
Total	71	20	12	4	2					104	
Percentage of total seed lots purchased for this reason	*68.3*	*19.2*	*11.5*	*3.8*	*1.9*						

Notes: * Friend, neighbour, stranger, family, *compadre*.
** Political candidate, agricultural/political organization, municipal government.
*** Seed distributor, veterinary shop, *despacho*.
More than one response per seed lot is possible; some farmers for which no information was provided have been eliminated.
Source: authors' calculation using 2004 and 2007 project survey data

indeed, this form of sourcing had dropped off a great deal). For seed lots sourced informally, ease of sourcing was the most important factor (44.4 per cent; 8 out of 18 seed lots) in choosing this source in 2004, followed by 'only known source' (27.8 per cent; 5 out of 18 seed lots). However, the importance of both of these reasons decreased by 2006, with price ('cheapest source') being the most important reason given for informal sourcing in 2006 (64.3 per cent; 9 out of 14 seed lots). Ease remained second most important (28.6 per cent; 4 out of 14 seed lots).

Transaction costs involved in acquiring seed are difficult to quantify, in part due to the presence of the seed subsidy. While individuals can apply directly to the SDR to receive the subsidy, organized groups of farmers have a better chance of receiving the subsidy (Hellin et al, 2009). Likewise, the seed distributors, who represent seed companies such as Pioneer, Monsanto and Christian Burkard, and who provide farmers with hybrid and OPV seed (both subsidized and unsubsidized), much prefer working with groups of farmers as this reduces their transaction costs. Such organization is usually done through the *ejido*, with the community leadership taking responsibility for compiling information on farmers' identities and their specific seed requests. Qualitative field methods revealed that such forms of organization played a significant role in farmers' ability to access seed at the subsidized price; but the costs of organization were not quantified in the surveys.

Other associated costs – including the transport of the seed to the village – may also be influenced by involvement in a farmers' group. Farmers purchasing large numbers of bags from individual sellers reported having received free delivery of these bags to the village, saving them both transportation costs and time (Hellin et al, 2009). Although there was no formal mechanism in place to ensure that all farmers would be able to take advantage of such a strategy, farmers reported paying less than 3 pesos per bag (approximately US$0.25) in seed transport costs in 2006. This price was much lower than the cost of a one-way trip on public transportation from any of these villages to regional centres where formal seed sources were located. This low average cost suggests that the strategy of negotiating the inclusion of transport costs into the seed price was widespread (Becerril, in preparation).

Information

Table 8.10 reports farmers' reason for choosing seed sources that they had used in the last five years. Almost all farmers (111 out of 113) reported having sourced seed from the formal sector in the last five years, while only 29 out of 113 (25.7 per cent) from social networks (informal sector). The most often cited reason for choosing a seed source was that it has the desired variety (77.9 per cent of farmers) followed by price (43.4 per cent of farmers).

Table 8.11 describes how farmers reported learning about the seed varieties they chose in 2004 and 2006. Direct observation of a variety's performance in the field was important in 2004 (31.8 per cent of farmers); but this decreased a

Table 8.10 *General evaluation of seed sources used (2001–2006)*

	*Social network**		*Formal seed distributor***		*Political/ government source****		*Total farmers citing reason*	
Only source with desired variety	5	17.2%	83	74.8%	0	0.0%	88	77.9%
Cheapest source	20	69.0%	22	19.8%	7	70.0%	49	43.4%
Easiest source	6	20.7%	8	7.2%	1	10.0%	15	13.3%
Most trusted source	2	6.9%	9	8.1%	1	10.0%	12	10.6%
Seed was gifted	0	0.0%	0	0.0%	1	10.0%	1	0.9%
Total farmers citing	29	100.0%	111	100.0%	10	100.0%	113	100.0%

Notes: These figures omit one farmer who named a local market as the most frequent source, both for reasons of the availability of the desired variety and cost.
* 'Social network' refers to friends, *compadres*, family and neighbours.
** 'Formal seed distributor' refers to veterinary shops, *despachos* and seed distributors.
*** 'Political/government source' refers to political candidates and *ejido* leaders.
Source: authors' calculation using 2004 and 2007 project survey data

great deal by 2006 (6.1 per cent). Meanwhile, recommendations from formal sources increase a great deal as a form of acquiring variety information (from 39.9 to 63.6 per cent). In terms of specific germplasm types, recommendations by formal sources dropped off for OPVs during this time period, but increased a great deal for hybrids. Recommendations through social networks were an important source of information about landrace varieties in both 2004 and 2006 (although the sample size for purchased seed is small).

Reports are only for purchased seed lots for the two years for which information was available (information not available for all seed lots).

Ad hoc knowledge acquisition (i.e. someone shows up promoting a certain seed; or the farmer hears about it on a radio, or happens to see it in a store) seems to disappear between 2004 and 2006. This could be a function of data collection (i.e. how the question was asked); alternatively, it might suggest that farmers are becoming more aware of the non-community sources through which they gain information about varieties.

Qualitative data suggest that the formal source of information has also changed in the last few years. During the first half of this decade, farmers' exposure to and information on improved maize varieties were linked to formal extension agents called *despachos*. The *despachos* worked with farmers to access a subsidized agricultural technical package that included subsidized seed. The *despachos* were, in turn, subsidized by the Fideicomisos Instituidos con Relación a la Agricultura (FIRA). FIRA supported the role of the *despachos* by providing a subsidy so that farmers could 'pay for' the technical package that the *despachos* offer. The subsidy fell from 70 per cent of the cost of the package in year one to 20 per cent by year four. The *despacho* was, hence, a public- and private-sector supported extension agent. According to FIRA, there were 20 *despachos* in 2001 and only 6 in 2006 (Hellin and Flores, 2007).

Table 8.11 *How farmers learned about seed variety (2004 and 2006)*

	Reported in both 2004 and 2006			*2004 only*		
	*Direct observation**	*Through a social network***	*Recommended by formal source****	*Someone came to offer it in the village*	*Other form of advertise-ment*****	*Total*
2004						
Landrace	0	1	0	0	0	1
Creolized	2	1	0	0	1	4
OPV	1	5	16	5	1	28
Recycled hybrid	0	0	1	0	0	1
Hybrid	44	25	42	2	1	114
Total	47	32	59	7	3	148
Percentage of total seed lots acquired using this source of information	*31.8*	*21.6*	*39.9*	*4.7*	*2.0*	
2006						
Landrace	2	4	1			7
Creolized	0	0	0			0
OPV	1	4	1			6
Recycled hybrid	0	3	0			3
Hybrid	3	19	61			83
Total	6	30	63			99
Percentage of total seed lots acquired using this source of information	*6.1*	*30.3*	*63.6*			

Notes: * 'Direct observation' refers to observation in the field or a demonstration plot.
** 'Social network' refers to information acquired via another farmer or a farmers' group.
*** 'Formal source' refers to extensionists, despachos and seed distributors.
**** Other forms of advertisement include radio, information and labels on the bag.
Source: authors' calculation using 2004 and 2007 project survey data

There are a number of reasons for the demise of the *despachos*. One of the farmers' complaints was that farmers had little say in the type of seed that they received as part of the technical extension package. In addition, the *despachos* became disillusioned because sometimes farmer groups paid them late (and sometimes not at all) for their extension provision. Many *despachos* have shifted their focus from the primary to secondary sector and particularly to the provision of micro-credit to small and medium-sized enterprises. The most important formal source of information on improved maize varieties is now, with a reduction in the numbers of *despachos*, the seed distributors.

Similarly, Table 8.12 shows how farmers acquired information about the seed source itself. Social networks emerge as being very important for learning about seed outlets, and increase in relative importance (even for hybrids) between 2004 and 2006. Meanwhile, direct observation decreased a great deal in importance, showing that farmers were less frequently learning about sources by

Table 8.12 *How farmers learned about seed source (2004 and 2006)*

	Social network[*]	*Direct observation*[**]	*From a government or political source*[***]	*Formal seed-sector source*[****]	*Ad hoc source*[*****]	*Totals*
2004						
Landrace	1	0	0	0	0	1
Creolized	1	1	0	0	1	3
OPV	16	1	6	2	1	28
Recycled hybrid	0	0	0	1	0	1
Hybrid	62	19	8	21	1	112
Total	80	21	14	24	3	145
Percentage of purchased seed lots for which seed source was identified by this information source	*55.2*	*14.5*	*9.7*	*16.6*	*2.1*	
2006						
Landrace	5	0	0	0	n/a	5
Creolized	0	0	0	0	n/a	0
OPV	3	0	0	2	n/a	5
Recycled hybrid	3	0	0	0	n/a	3
Hybrid	52	1	1	27	n/a	80
Total	63	1	1	29	0	93
Percentage of purchased seed lots for which seed source was identified by this information source	*67.7*	*1.1*	*1.1*	*31.2*	*0*	

Notes: * 'Social network' refers to a neighbour, family member or farmers' group.
** Direct observation refers to observation in an experimental plot.
*** Government or political source refers to an *ejido* leader, the COPLADER or an extensionist from the municipal president's office.
**** 'Formal seed-sector' source refers to a *despacho* or a promoter from a business.
***** An 'ad hoc' source refers to advertising or other publicity.
n/a = not available.
More than one response per seed lot is possible.
Source: authors' calculation using 2004 and 2007 project survey data

visiting demonstration plots or fields. The formal seed sector gained importance in information provision, while *ad hoc* information sources and government/political sources dropped off in importance during the period.

Table 8.13 reports farmers' assessment of their confidence in the seed sources that they had used. Respondents generally gave favourable assessments of the sources that they had chosen (farmers were asked to assess their level of confidence as 'a lot', 'average', 'some' and 'none'; but the only responses given were 'a lot' and 'average'.) Furthermore, the majority of the responses were 'a lot'. When asked to give reasons for their assessment (positive or negative), the

Table 8.13 *Evaluation of seed sources used (2001–2006)*

	Social network		*Formal source*		*Political/government source*		*Market*		*Total favourable*	*Percentage*	*Total less favourable*	*Percentage*
	+	–	+	–	+	–	+	–				
Has best-quality seed	25		98	2	6		1		130	88.4	2	28.6
Sells at low price		1			2	1			2	1.4	2	28.6
Just to try it out	1								1	0.7	0	0.0
Farmer's own seed	1								1	0.7	0	0.0
Has been provider for a long period			12	1					12	8.2	1	14.3
Gives credit			1	1					1	0.7	1	14.3
The crop rotted in the field					0	1			0	0.0	1	14.3
Total	27	1	111	4	8	2	1	0	147		7	

Note: + is a shorthand for 'favourable assessment; while – is shorthand for 'less favourable assessment'.
Source: authors' calculation using 2004 and 2007 project survey data

most frequently cited reason was the quality of the seed, although in terms of a percentage of responses, selling at a low price, was also important for political/government sources. The length of the relationship with the seed provider was also cited as an important reason for formal seed sources.

The data suggest that farmers are using both formal and informal sources for their information. Informal networks (i.e. social networks) are important for finding out which seed sources exist. When deciding which seed to purchase, farmers rely increasingly on formal-sector information sources. Meanwhile, farmers continue to rely on social networks for information about farm-saved seed.

Diversity impacts of the formal seed sector

We have shown that maize farmers in La Frailesca have adopted improved germplasm widely and increasingly rely on formal channels for seed. In spite of these changes, the informal seed system coexists with the formal seed system. Evaluating the diversity impacts of this coexistence is not obvious, however, as the presence of a formalized seed market may have both diversifying and homogenizing effects on the local seed supply. If commercial seed does not offer new traits or is genetically homogeneous, the presence of a strong formal seed system may decrease local diversity. Conversely, commercial seed may offer new genetic traits and/or offer higher diversity for those traits.

Of course, if the coexistence between the formal and informal seed system is stable, diversity impacts will depend on the extent to which the two systems are connected. Only significant gene flow from the formal to the informal seed system will cause diversity changes, either positive or negative, in the informal sector. Such gene flow may occur both by the adoption of commercial seed (Bellon et al, 2007) or by pollen flow. The first mechanism has the potential to cause fundamental changes in the composition of the informal seed system. The second, although more gradual, may have profound impacts upon local germplasm by what has been called 'genetic swamping', or the replacement of the local gene pool by introduced genes (Lenormand, 2002).

We appraised the diversity effects of the formal seed sector in La Frailesca by describing the level of uniqueness and diversity offered by different kinds of seed. Since local names for informal-sector seed can be uninformative of genetic identity, comparison based on variety names may not be appropriate. For example, in 2004, 23 different hybrids and four OPVs were being sold by seven private companies and one farmer co-operative (Flores et al, 2004). Nevertheless, we have no *a-priori* basis for concluding that this diversity in nomenclature corresponds to genetic diversity. We therefore produced estimates of mean levels of differentiation for molecular markers and agronomic traits that were based on comparisons between individual seed lots, without taking

local nomenclature into consideration. Detailed results are reported in van Heerwaarden et al (2009), but are summarized below and in Table 8.14:

- Improved varieties, including creolized maize, are clearly distinct from local landraces, both in terms of agronomic traits and marker differentiation. The formal sector may thus provide unique traits in addition to those offered by traditional landrace varieties.
- Although the group of traditional landraces shows the highest diversity for agronomic traits, diversity ranking of the different kinds of seed depends on the traits under consideration. Hybrids, in particular, are the most diverse group in terms of marker frequencies. They also show relatively high diversity for vegetative and flowering traits. In terms of ear traits, hybrids show diversity on a par with that observed for OPVs and creolized varieties. This suggests that the actual diversity impact of the replacement of informal with formal seed likely depends on the traits considered.
- In spite of having a rather diverse local nomenclature, creolized varieties were the least diverse for all traits (see Table 8.14). They showed little evidence of genetic change with respect to their ancestral varieties in spite of having being replanted for many years. Complete replacement of local landraces with creolized varieties would, hence, likely lead to a reduction in genetic diversity. Partial substitution of landraces could have a positive effect on informal seed diversity, owing to the unique traits offered by creolized varieties, depending on the magnitude of replacement.

These results indicate that extensive seed-mediated gene flow in the form of creolization could be detrimental to diversity within the informal seed system. Our research (reported in detail in van Heerwaarden et al, 2009) hence shows that the adoption of formal seed into the informal seed system is, indeed, very common. Creolized seed made up the largest proportion of informal seed in several localities. In fact, farmers tend to use the word criollo for landrace and creolized varieties alike, and considerable effort is often required to obtain the correct classification for informal seed. We compared diversity within the informal seed system with and without including creolized varieties. We found that creolization has, indeed, caused a reduction in overall diversity compared to the

Table 8.14 *Diversity rankings (with ties), based on agronomic traits and molecular markers, for different kinds of formal and informal seed (highest =1; lowest = 4)*

	Source	*Ear traits*	*Plant traits*	*Marker differentiation*
Hybrids	Formal	3	2	1
OPVs	Formal	3	3.5	3
Creolized	Informal	3	3.5	4
Landraces	Informal	1	1	2

Source: van Heerwaarden (2007)

Table 8.15 *Model-based estimates for pollen flow*

Source type	*Percentage pollen*
Criollo	1.0
Improved	1.1
Total	2.1

Source: van Heerwaarden (2007)

diversity found within the traditional landraces. Nevertheless, this reduction has been relatively minor compared to what would be found in case of complete replacement of landraces with creolized varieties (van Heerwaarden et al, 2009).

Pollen-mediated gene flow from improved varieties into landraces was estimated at 1 per cent and was found to be the same as pollen flow from other landraces (see Table 8.15). The main factor that limited pollen flow was found to be temporal, rather than spatial, separation. Whereas different kinds of seed were usually planted close enough together to allow for pollen flow to occur, there was often a large difference in flowering time (up to 28 days) between the different fields. Based on our limited results, therefore, it seems that in spite of the abundance of improved varieties in La Frailesca, pollen flow into traditional varieties is not particularly high.

Our estimate of pollen flow is in line with the levels of cross-pollination previously reported between landrace populations (see Louette, 1997). This suggests that, at present, 'genetic swamping' may not be a concern as we may expect the same selective forces that have maintained current landrace diversity in the face of similar levels of gene flow to continue to preserve diversity in the future. At the same time, these results mean that the transmission of new traits from modern varieties into landraces by means of pollen will be slow. This result might help to explain why so little genetic change seems to have occurred in the creolized seed lots that were characterized in this study.

Conclusions

Research in La Frailesca suggests that farmers access the genetic resources available in local landraces primarily through non-market exchanges, including on-farm seed-saving and social networks. Meanwhile, access to the genetic resources contained in improved varieties is mediated by high prices, which may be lowered when farmers access a state-sponsored subsidy; but accessing this subsidy, in turn, implies internalizing the transaction costs of organizing. However, farmers may find these prices and transaction costs worthwhile due to the level of information implied by the formal market, which allows farmers greater certainty of the identity, genetic content and reliability of a specific seed, and also allows them to discern whether they would like to make a repeat purchase. While diverse germplasm is available to farmers through both the

formal and informal systems, the nature of this diversity may change if farmers reduce their use of local landraces.

The seed market in La Frailesca contrasts with others detailed in this book in terms of access, availability and information. Theoretically speaking, *information* should be the major strength of the switch to formal seed sourcing, observed in La Frailesca, because the plant-breeding process should provide the farmer with a reliable source of information about the seed that he or she is purchasing, and he or she should purchase it from a specific reputable vendor/company. The latter implies that the farmer also has an option of complaining or discontinuing purchase from this source in the event that the seed does not perform well.

Although this research did not measure the difference between seed sellers' claims about variety identity and the actual characteristics exhibited by the seed when planted (as was done in Chapter 6 in this volume), qualitative research methods revealed few complaints about inaccurate information from the formal sector. Furthermore, farmers' tendency to repeat purchases of hybrid seed over time would suggest that they have found the product satisfactory. These observations imply that, to some extent, farmers are benefiting from greater availability and/or accuracy of information by sourcing their seed from the formal sector.

The results also suggest that there is an 'information disconnect' between the formal and informal systems. Generally speaking, farmers source improved and non-improved seed through two parallel systems (i.e. the formal market and informal social networks). Although these two systems are not totally separate from each other, each system provides only a subset of information about the seed that it carries. Presumably, information in the informal system would be more fragmented than information in the formal system (i.e. each individual farmer has experience only with varieties that he or she has tried or directly observed), while information in the formal system might be more centralized. This would imply that farmers seeking information about landrace or creolized varieties face greater transaction costs than those gathering information about varieties that they would source through the formal system.

While switching to formal-sector seed sourcing likely implies important information benefits, access to seed may become more complicated in this market. First, prices for formal-sector improved seed are higher than farm-saved seed; and, second, accessing the subsidy that lowers those costs requires farmer organization. The availability of the seed subsidy seems to have facilitated access through the 2006 season; but in 2007, there was uncertainty as to whether the subsidy would continue. When asked in the 2007 survey whether they would continue purchasing hybrid seed if the subsidy were removed, 36.7 per cent of farmers responded that they would not (Becerril, 2008). These observations suggest that access to the formal seed market continues to be heavily mediated by government intervention. Furthermore, the influence of political sources on seed acquisition in 2004 shows that a transition to formal-sector seed does not

necessarily imply a move towards a market governed by pure supply-and-demand forces.

Finally, these observations plant a series of questions regarding the *availability* of diversity to farmers within the La Frailesca system. Currently, farmers have access to a wide range of diversity in that the materials available in the formal and informal seed-sectors represent a wide range of germplasm types. However, it is unclear what these changing sourcing patterns imply for diversity in the long term and also for the persistence of landraces specifically. Data from the most recent survey provide a counterpoint to the trends observed in 2001 to 2004, showing a 'rebound' in the use of landrace and creolized material. Farmers' continued reliance on farm-saved seed and landraces suggests that the informal seed system continues to be robust and resilient, even in a period when the overall emphasis on maize is decreasing.

Our study of genetic and agronomical heterogeneity within landrace, creolized and commercial seed lots shows the consequences for diversity of the adoption of improved seed. Complete replacement of traditional types with improved varieties would constitute a loss of certain agronomic traits, whereas coexistence of the two types of seed may constitute an increase in local diversity. However, it is relevant to note that within the informal sector, creolized maize is the most homogeneous group for all measured criteria. Hence, questions remain about the long-term impacts of introducing improved germplasm into the system, particularly given the observation that creolized varieties tend to be less diverse than either purchased improved seed or landraces. The ramifications of the development of a market for formal-sector maize seed in La Frailesca for agricultural development and human well-being will require a long-term process of monitoring.

Notes

1 Although an agricultural census of Mexican farmers was carried out in 2007, the data had not yet been made publicly available at the time of writing. In the previous census, carried out in 1991, it was estimated that 8 per cent of maize producers (those who cultivated more than 20ha of farmland) accounted for some 35 per cent of maize production. Meanwhile, the 62 per cent of producers who cultivated 5ha or less accounted for only 27 per cent of total production (García Rañó and Keleman, 2007).

2 The relative advantages of La Frailesca farmers are confirmed by a comparative study of small-scale farming communities in Chiapas and Oaxaca (Bellon et al, 2007), which surveyed small-scale farmers in six La Frailesca communities representing a cross-section of marginalization levels. In comparison to their Oaxacan counterparts, La Frailesca farmers were more commercially oriented and more likely to use improved maize seed. Their agricultural landholdings were more than double in size of those managed by the Oaxacan farmers surveyed, and they used higher rates of chemical inputs (Bellon et al, 2007, p243).

3 A previous survey was carried out in 2001 with the same panel of farmers; but data from this survey are not reported here.

4 In analysing this data, the panel sample of 109 farmers was used to analyse changes in area planted to different maize types and number of farmers planting each type of maize (see Table 8.3). However, for ease of calculation, analyses of seed sources were made by seed lot (i.e. by each type of seed that a farmer reported planting). Hence, the full sample of seed lots analysed in Tables 8.4 to 8.13 exceeds the full number of farmers in the survey, and includes both farmers present in both years and farmers who were interviewed in only one year or the other.
5 Here we distinguish 'political' sources as sources that were directly associated with an election or a targeted governmental campaign. However, it is important to recognize that the lines between political and formal sources are blurry; formal sources are not necessarily apolitical since access to them is frequently mediated by the government-sponsored seed subsidy, which could also be considered an element of targeted government campaigning.
6 The exchange rate in September 2006 was approximately US$1 to 11 Mexican pesos.

References

Appendini, K. (2001) *De la milpa a los tortibonos: La reestructuración de la política alimentaria en México*, 2nd edition, El Colegio de Mexico and United Nations Institute for Social Development: Mexico City, Mexico

Becerril, J. (2008) 'Economic analysis of Chiapas Maize 2006 Dataset', unpublished report for the Agricultural and Development Economics Division (ESA) of the Food and Agricultural Organization

Bellon, M. R. and Hellin, J. (in preparation) 'Government intervention as an enabler of the private seed sector: Impacts on varietal change among small-scale maize farmers in Chiapas, Mexico'

Bellon, M. R., Adato, M., Becerril, J. and Mindek, D. (2007) 'Improved maize germplasm, creolization, and poverty: The case of Tuxpeño-derived material in Mexico', in M. Adato and R. Meinzen-Dick (eds) *Agricultural Research, Livelihoods and Poverty: Studies of Economic and Social Impacts in Six Countries*, Johns Hopkins University Press, Baltimore

Brush S. B. and Perales, H. R. (2007) 'A maize landscape: ethnicity and agro-biodiversity in Chiapas, Mexico', *Agriculture, Ecosystems and Environment*, vol 121, pp211–221

Cecarelli, S. (1989) 'Wide adaptation: How wide?', *Euphytica*, vol 40, pp197–205

CONAPO-PROGRESA (Consejo Nacional de Población y Programa de Educación, Salud y Alimentación) (2000) *Indices de Marginación 1995*, CONAPO-PROGRESA, Mexico

CONEVAL (Consejo Nacional de Evaluación de la Política de Desarrollo Social) (2009) *Mapas de Pobreza en México*, www.coneval.gob.mx/mapas/, accessed 10 June 2009

Erenstein, O., Cadena, P., de la Piedra, R. and Lopez, A. (1998) *Una vez mas, la adopción de la conservación de residuos en La Fraylesca*, CIMMYT, Chiapas, Mexico

ETC Group (2008) *Who Owns Nature? Corporate Power and the Final Frontier in the Commodification of Life*, Communiqué no 100, www.etcgroup.org/en/materials/publications.html?pub_id=707, accessed 20 November 2008

FAOSTAT (2009) *Food Balance Sheets: Mexico, 2003*, Food and Agriculture Organization of the United Nations, http://faostat.fao.org/site/368/default.aspx, accessed 19 February 2009

Flores, D., Ramirez A. and Bellon, M. R. (2004) 'Characterization of the formal maize seed supply system in the Frailesca region, Chiapas, Mexico', unpublished report for the Agricultural and Development Economics Division (ESA) of the Food and Agricultural Organization

García Rañó, H. and Keleman, A. (2007) *La crisis de la tortilla del 2007: Coyuntura, o ¿falla estructural?*, Oxfam International, Mexico City

Hellin, J. and Flores, D. (2007) *Assessing the Impact of Seed Supply Systems and Value Chains on Maize Diversity*, Report to the Agricultural and Development Economics Division (ESA) of the Food and Agricultural Organization as part of the project Using Markets to Promote the Sustainable Utilization of Crop Genetic Resources, FAO, Rome

Hellin, J., Griffith, A. and Albu, M. (2005) 'Mapping the market: Market-literacy for agricultural research and policy to tackle rural poverty in Africa', in F. R. Almond and S. D. Hainsworth (eds) *Beyond Agriculture – Making Markets Work for the Poor*, Proceedings of an international seminar, 28 February–1 March 2005, Westminster, London, UK, Crop Post-Harvest Programme (CPHP), Natural Resources International Limited, Aylesford, Kent, and Practical Action, Bourton-on-Dunsmore, Warwickshire, UK, pp109–148

Hellin, J., Lundy, M. and Meijer, M. (2009) 'Farmer organization, collective action and market access in Meso-America', *Food Policy*, vol 334, pp16–22

Hibon, A., López Báez, W. and De la Piedra Constantino, C. R. (1989) *Mejorando la implementación de una política agrícola partiendo del campo del agricultor: El caso de la distribución de fertilizantes nitrogenados para la producción de maíz de temporal en La Fraylesca, Chiapas, Mexico*, CIMMYT, Mexico City, Mexico

Keleman, A., Hellin, J. and Bellon, M. R. (2009) 'Maize diversity, agricultural policy, and farmers' practices: Lessons from Chiapas, Mexico', *The Geographical Journal*, vol 175, no 1, pp52–70

Keleman, A., Hellin, J. and Flores, D. (2008) *Agricultural Initiative for Maize in Mexico to Support the Implementation of the North America Free Trade Agreement: Estado de México Market Study*, CIMMYT document completed in fulfilment of requirements of a USDA grant, CIMMYT: El Batán: Mexico

King, A. (2006) *Ten Years with NAFTA: A Review of the Literature and Analysis of Farmer Responses in Sonora and Veracruz, Mexico*, CIMMYT Special Report 06-01, CIMMYT, Mexico City, Mexico

Lenormand, T. (2002) 'Gene flow and the limits to natural selection', *Trends in Ecology and Evolution*, vol 17, pp183–189

Louette, D. (1997) 'Seed exchange among farmers and gene flow among maize varieties in traditional agricultural systems', in J. A. Serratos, M. C. Wilcox and F. Castillo-Gonzalez (eds) *Gene Flow Among Maize Landraces, Improved Maize Varieties, and Teosinte: Implications for Transgenic Maize*, CIMMYT, Mexico

Ma, B. L., Subedi, K. D. and Reid, L. M. (2004) 'Extent of cross-fertilization in maize by pollen from neighboring transgenic hybrids', *Crop Science*, vol 44, no 4, pp1273–1282

Messeguer, J., Penas, G., Ballester, J., Bas, M., Serra, J., Salvia, J., Palaudelmas, M. and Mele, E. (2006) 'Pollen-mediated gene flow in maize in real situations of coexistence', *Plant Biotechnology Journal*, vol 4, no 6, pp633–645

O'Brien, K. L. (1998) *Sacrificing the Forest: Environmental and Social Struggles in Chiapas*, Westview Press, Boulder, CO

Ortega-Packza, R. (1999) *Genetic Erosion in Mexico. Genetic Erosion of Crop Populations in Centers of Diversity: A Revision*. Proceedings of the Technical Meeting on the Methodology of the FAO World Information and Early Warning System on Plant Genetic Resources held at the Research Institute of Crop Production, Prague, Czech Republic 21–23 June 1999, http://apps3.fao.org/wiews/Prague/Paper10.jsp#Mexico, accessed 14 March 2007

Perales, H. R. and Hernández Casillas, J. M. (2005) 'Diversidad del Maíz en Chiapas', in M. González-Espinosa, N. Ramírez Marcial and L. Ruiz Montoya (eds) *Diversidad Biológica de Chiapas*, Plaza y Valdés/ECOSUR/COCYTECH, Mexico City, pp337–355

Puyana, A. and Romero, J. (2006) *10 Años Con el TLCAN*, FLACSO and El Colegio de México, México

Rosegrant, M. W., Msangi, S. M., Sulser, T. and Valmonte-Santos, R. (2006) 'Biofuels and the global food balance', in P. Hazell and R. K. Pachauri (eds) *Bioenergy and Agriculture: Promises and Challenges*, 2020 Focus 14, Brief 1 of 12, International Food Policy Research Institute, Washington, DC

Sain, G. and López-Pereira, M. A. (1999) *Maize Production and Agricultural Policies in Central America and Mexico*, Documento de Trabajo de Economía no 99-02, CIMMYT, México

Uribelarrea, M., Carcova, J., Otegui M. E. and Westgate, M. E. (2002) 'Pollen production, pollination dynamics, and kernel set in maize', *Crop Science*, November–December, vol 42, no 6, pp1910–1918

van Heerwaarden, J. (2007) 'Population genetics of traditionally managed maize: farming practice as a determinant of genetic structure and identity of maize landraces in Mexico', Wageningen University, Wageningen

van Heerwaarden, J., Hellin, J., Visser, R. and van Eeuwijk, F. (2009) 'Estimating maize genetic erosion in modernized smallholder agriculture', *Theoretical and Applied Genetics*, vol 119, pp875–888

Yúnez-Naude, A. (2003) 'The dismantling of CONASUPO, a Mexican state-trader in agriculture', *The World Economy*, vol 26, pp97–122