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The Dynamics of Farmers' Maize Seed Supply Practices in the Central Valleys of Oaxaca, Mexico

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Summary. — What are the organizing principles that underlie and help shape farmers' seed supply practices in the Central Valleys of Oaxaca? And what are the implications of these practices for maize genetic diversity and the introduction of improved varieties? Local maize seed supply was studied using both qualitative and quantitative methods and a series of factors that influence local seed supply was analyzed. Together they constitute a set of flexible and dynamic practices, which embrace both conservation and innovation aspects. Implications for on-farm conservation and introduction of improved varieties are discussed.

Key words — Latin America, Mexico, maize, social seed system, on-farm conservation

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1. INTRODUCTION

Seed is a fundamental input for agriculture and probably the single most important input in all crop-based farming systems. More than being the basis of production for the majority of the world's crops, seed determines the upper limit on yield and therefore on the ultimate productivity of all other inputs (Cromwell, 1990). Securing access to seed of the desired varieties and of good quality is therefore a very important issue for farmers and a concern for society to achieve food security.

Informal seed systems [1] are still the prevailing source of seed in developing countries, and many studies have stressed their importance (Almekinders, Louwaars, & de Bruijn, 1994; Seboka & Deressa, 2000; Sperling, Heidegger, & Buruchara, 1995; Subedi, Chaudhary, & Sthapit, 2003; Thiele, 1999). Several authors have pointed out that informal systems are mostly based on traditional social alliances and family relations, cast in the context of mutual interdependence and trust, often forming dynamic networks with a high degree of complexity (Almekinders *et al.*, 1994; Seboka & Deressa, 2000). Nevertheless, relatively little is known about how these systems function. As stated by Seboka and Deressa (2000, p. 250): "The flow of seeds or farmer-to-farmer exchange of seed is a neglected area of research. There is an urgent need to understand more in detail the process of farmer-to-farmer exchange of seed."

Seed is also an important source of germplasm for crop improvement, and a key element in the management and conservation of crop genetic resources (Almekinders, 2001; Almekinders & de Boef, 2000; Bellon, 2004; Jarvis *et al.*, 2000; Orlove & Brush, 1996). Access to a wide range of genetic diversity allows farmers and plant breeders to adapt a crop to heterogeneous and changing environments, developing cultivars with high levels of adaptation to biotic and abiotic stresses and to human preferences. Consequently conservation of genetic resources is crucial to address future challenges in research and crop improvement in order to intensify agricultural production and increase food supply, and to try to respond to farmers' different requirements and preferences.

Studies on these aspects often portray farmers as the caretakers of important crop genetic resources. However, most farmers do not maintain crop genetic resources merely for the sake of conservation. Rather, many farmers value local crop genetic resources and make special use of diverse crop varieties in their production system. Decisions regarding varietal choice often depend on multiple considerations and not just yield. Such issues can be illuminated by in-depth, qualitative studies (Orlove & Brush, 1996).

Mexico is a center of domestication and diversity for maize (Matsuoka *et al.*, 2002; Piperno & Flannery, 2001; Sanchez, Goodman, & Stuber, 2000), and farmers continue to play a key role in the maintenance of this diversity (Bellon, 2004; Hernandez, 1985; Perales-Rivera, Brush, & Qualset, 2003). According to Morris and López-Pereira (1999) approximately 80% of the area planted to maize in Mexico is planted with recycled seed, that is, seed selected by farmers from the previous harvest.

The structure and evolution of maize genetic diversity in the Central Valleys of Oaxaca depend on a combination of gene flow and farmers' selection (Pressoir & Berthaud, 2004). While gene flow allows new genes to enter the system, farmers' seed selection, which is strongly influenced by local preferences and culture, allows for the differentiation between varieties from the same farmer or between farmers (Pressoir & Berthaud, 2004). [2]

The dynamics of farmers' seed supply practices have important implications, both for the conservation of crop genetic resources on-farm and for the design and implementation of interventions to support conservation (Bellon, 2004; Subedi *et al.*, 2003). Moreover, in a broader perspective they also have important implications for the introduction of new varieties and seed sector development.

This paper provides an overview of a range of factors influencing farmers' local seed transaction practices. [3] Together, these constitute a dynamic set of practices which, on the one hand, ensure an efficient and low-cost supply of a diverse array of maize germplasm to farmers in the study communities, and, on the other hand, are efficient in maintaining and conserving maize genetic diversity at the local level.

2. STUDY SITES AND METHODOLOGY

In the Central Valleys of Oaxaca, maize agriculture continues to play a significant role as a source of food security, local maize products, and income. Farmers in this region value their landraces and continue to plant them, thereby contributing to the conservation of maize biodiversity (Bellon *et al.*, 2003; Smale *et al.*, 2003). A formal seed sector has yet to develop in this region, and most farmers produce their own maize seed year after year or rely on other farmers to acquire seed.

The study presented here was carried out in six communities in the Central Valleys of Oaxaca: San Pablo Huitzo, Santo Tomás Mazaltepec, San Lorenzo Albarradas, San Agustín Amatengo, Valdeflores, and Santa Ana Zegache (Table 1). Average farm size is 3.5 ha, and farming systems in all six communities are characterized by low productivity (Smale *et al.*, 1999). Yearly mean temperature in the region is 18–22 °C, with an average annual precipitation of 600–1000 mm (INEGI, 2001b). Maize, beans, and squash are the most common crops, with maize being sown on average on more than 90% of the landholding areas. Maize agriculture is dominated by local landraces: only in the area of San Pablo Huitzo, which also had the highest average percentage of irrigated maize, was the area planted to improved maize seed, slightly significant (Smale *et al.*, 1999).

The population in the study area is predominantly Spanish speaking, but in Santa Ana Zegache and Santo Tomás Mazaltepec more than 30% belong to the Zapotec ethnic group and speak Zapotec as a first language. In both communities more than 97% of Zapotec speakers also speak Spanish (INEGI, 2001a).

Agriculture is the major source of income for nearly all households, whether located in better or poorer maize production zones. Nonfarm employment is an important source of income for about one-quarter of the farmers. A similar overall percentage of households depend on remittances, although the percentage varies considerably among some of the study communities, particularly in Huitzo, Mazaltepec, and Amatengo (Smale *et al.*, 1999).

As the CIMMYT/INIFAP project was conducted in the same area, considerable background information on the study communities

Table 1. *Key characteristics of the six study communities*

Characteristics	Communities					
	San Pablo Huitzo[a]	Santo Tomas Mazaltepec	San Lorenzo Albarradas[a]	San Agustin Amatengo	Valdeflores	Santa Ana Zegache[a]
Population[b]	4,685	1,939	1,857	1,752	1,246	2,543
Altitude (masl)[c]	1,700	1,660	1,810	1,360	1,460	1,480
Maize yield potential	Good	Poor	Poor	Poor	Good	Good
Mean						
No. farmer varieties[d]/ household in 1997	1.26	1.21	2.13*	1.10	1.11	1.98*
Farm size 1996 (ha)	2.44**	3.91	4.01	2.84**	3.87	3.46
% Land privately owned	49.60*	0.00	1.00	27.42*	0.00	100*
% Maize area irrigated	54.2*	15.7	8.10	11.90	3.78**	0.17**
% Maize area in improved seed	0.14*	0.00	0.04	0.00	0.00	0.01
Percent						
Households dependent on local nonfarm income	40*	28	30	25	25	15*
Households dependent on remittances	3*	13*	23*	38	25	25

Sources: Smale *et al.* (1999) and INEGI (2001a).
[a] Communities where the seed flow tracer study took place.
[b] Total population in relevant localities within the municipality (INEGI, 2001a).
[c] Altitude of municipal center (INEGI, 2001a).
[d] Crop populations that a group of farmers recognize as distinct units. A farmer variety is not a variety in the sense of commercial agriculture, where a variety should be distinct, uniform and stable.
* Mean (frequency) significantly higher (different) using one-tailed *t*-test (chi-squared test), .05 significance level.
** Mean significantly lower using one-tailed *t*-test .05 significance level.

was already available, including a random sample of 240 households. The communities were selected for the contrasts they represented in terms of maize yield potential and dependency on nonfarm income (Smale *et al.*, 1999). For all the activities of this study, informants were selected based on information from the previous study representing different age groups, gender, ethnicity, economic status, and level of formal education to ensure that the diversity of different social groups was captured.

The original objective was to determine the role of collective action in on-farm conservation of maize genetic diversity. However, as research progressed no evidence of institutions of collective action specific to seed acquisition was identified. As a consequence the research focus was redirected toward a more general analysis of how farmers access seed of diverse maize varieties, and the reasons behind the apparent lack of collective action in this particular respect (Badstue *et al.*, 2006).

The research employed both qualitative and quantitative methodologies, including in-depth, semi-structured ethnographic interviews, including an initial survey with key informants to identify relevant issues and questions; focus group discussions; and a quantitative tracer study of seed flows among farm households. The different methods complemented each other and allowed key issues to be addressed from several angles.

Early in the research process, in-depth ethnographic interviews were conducted with 22 key informants from the three most contrasting of the six communities in terms of maize yield potential, dependency on nonfarm income, and ethnicity (Smale *et al.*, 1999): Santa Ana Zegache, San Lorenzo Albarradas, and San Pablo Huitzo, as part of an initial assessment of local practices for accessing seed of diverse maize materials. These first interviews were carried out in these three communities only, due to the labor intensive and time consuming character of the methodology. The data gathered during these interviews were later confirmed in the focus groups discussions and in the tracer study.

Twelve focus group discussions were carried out—one with men and one with women in each of the six communities. In total, 46 women and 58 men participated. These discussions, which provided a great amount of valuable information, covered the relative importance of seed loss as a vulnerability factor faced by farmers and the mechanisms that guide seed transactions. Focus group results were remarkably similar across communities and gender.

For the survey-based seed flow tracer study, which involved male and female representatives from 153 farm households, we focused again on the same three communities where the initial interviews were conducted. This was justified because the results of the focus group discussions suggested that the conditions of these three communities were representative for all six, and because the tracer study was very labor intensive and the resources limited. In the tracer study, we followed the flows of seed among selected farm households, paying special attention to farmers' explanations about the transactions: why they had engaged in a transaction, with whom, and what the significance of the transaction was, among other factors. A total of 516 transactions of both incoming and outgoing flows were recorded. Using criteria similar to those described for the selection of informants, 10 households in each community were selected as the point of departure. After a first round of interviews, households that gave or received seed from each of the original 30 households were located and queried in a second round of interviews, and so on, until each of the original households had led to an average of four additional households being visited. [4]

3. SEED

(a) *The distinction between grain and seed*

From a biological perspective, any healthy maize kernel could serve as either seed or grain for consumption. However, farmers in the study area clearly distinguish kernels as *seed* for planting or as *grain* for consumption or sale. "Seed" represents a portion of the kernels from the farmers' harvest that has been carefully selected based on a set of specific criteria, according to which farmers decide from which ears to select the kernels to be used as seed, as well as which specific kernels on these ears to define as seed. As documented by Smale *et al.* (1999), farmers' seed selection criteria tend to emphasize aspects related to ear and grain health and size, and grain filling. However, other factors may also play a role, for example, grain color or other local perceptions associated with what makes a "good" seed.

In this process farmers exercise selection in an attempt to enhance favored varietal traits and lessen the influence of undesired ones. This ensures that certain traits are passed to the next generation at a higher frequency. Furthermore, these traits are what define a variety in the eyes of farmers, and studies have argued that this selection process plays an important part in what structures diversity in farmers' fields (Bellon & Brush, 1994; Louette, Charrier, & Berthaud, 1997; Pressoir & Berthaud, 2004). As demonstrated by Pressoir and Berthaud (2004) the dynamics of maize genetic diversity is a combination of gene flow and selection; without farmers' seed selection, maize populations in this region would not show the great morphological diversity observed.

Meanwhile, smallholders in the Central Valleys of Oaxaca generally refer to maize kernels as *grano* or grain, without specifying its intended use. Grain can be used for human consumption, animal feed, or sale. It has not *yet* been classified according to its intended use. Its destiny is therefore not unequivocal. By contrast, once seed has been selected it is destined specifically for planting, and hence treated in a different manner.

In spite of the seemingly clear distinction between seed and grain, farmers may sometimes use grain as seed. This occurs mainly in relation to smaller quantities of grain or during circumstances when it is difficult to obtain seed, for example, due to lack of resources. Under these circumstances a farmer may decide to acquire grain rather than seed, and subsequently select seed from this. However, as grain is generally managed less rigorously than seed, this procedure can entail additional risks with regards to seed quality. Although a clearly defined concept of seed exists (selected, clean, and of good quality), it is not rigid or static. Rather, the concept of seed is dynamic and negotiable, depending on the circumstances. This demonstrates the flexibility in farmers' categories and inclination toward experimentation and practical solutions.

(b) *The lack of transparency in seed*

Seed of good quality and with adequate production characteristics for the particular location is fundamental for agriculture; however, these aspects can be difficult to assess when acquiring seed. Seed is not transparent (Morris, Rusike, & Smale, 1998)—the traits and performance of the plants that will grow from it cannot be assessed by merely looking at the seed. In principle, one cannot know this until the seed is planted and the maize develops.

Environmental factors play an important role in crop performance, however, some crops respond stronger than others across different environments. Maize exhibits what plant breeders call a high genotype-by-environment interaction, meaning that its performance across different agro-ecological environments depends on its specific genetic make-up. In other words, a genotype or maize "variety," which performs well in one environment, may not do so in another. [5]

To some degree seed quality is also subject to the issue of nontransparency. Seed quality is constituted by a range of factors and can be difficult to assess, in particular the seed's ability to germinate. Age, pathogens, or inappropriate storage may affect germination, but these factors are not necessarily visible to the human eye.

Even though they inspect the seed before acquisition, farmers depend largely on the quality of the information offered by the seed provider with regards to traits and consumption characteristics, environmental adaptation, and seed quality. Farmers in the study area are aware of both the lack of transparency of seed and the genotype-by-environment characteristic. One clear indication of this was, for example, that during the focus group discussions, adaptation to local agro-ecological conditions was one of the first things farmers in all study communities mentioned as important when acquiring maize seed (Badstue, 2004; Badstue, Bellon, Juárez, Manuel Rosas, & Solano, 2003).

4. USING OWN SEED

The foundation of maize seed supply in the study communities is farmers' practice of selecting seed from the previous harvest and saving it for the next planting season. Of the farmers who participated in the seed flow tracer study, 75.8% relied entirely on their own seed in 2001. Furthermore, Smale *et al.* (1999) reported that approximately 90% of all seed lots in the study communities were selected by farmers from the previous harvest, while the rest were acquired almost entirely from other farmers.

According to informants, both in focus group discussions and individual interviews, selecting and saving seed provides a sense of security, as well as a chance to save money.

Once seed is selected and safely set aside, one can rest assured that the seed for the next planting season is secured. Furthermore, the seed will be available when it is needed so that the farmer will not incur planting delays. One can therefore avoid spending money and/or time acquiring seed at the last moment before planting, which is when prices typically increase and many households are struggling to raise the means necessary for land preparations, planting, etc.

Farmers' seed selection practices in the study area reflect both the genotype-by-environment consideration and the issue of seed security: Knowing the performance of the plants the seed came from; farmers select maize seed according to a set of characteristics that they perceive as favorable in terms of their own particular needs. Due to social, cultural, and environmental conditions, a variety that is appropriate for one farmer may not necessarily be appropriate for another. Hence, what better option to fit one's needs and preferences than using the seed that one knows and has selected?

Moreover, for some of these farmers, their own maize seed is associated with a certain affection value (Badstue *et al.*, 2005). This aspect surfaced many times during individual interviews, and was also mentioned by farmers during focus group discussions. Seed is often inherited, passed on from parents to children when the latter start farming independently. Often, the seed has been in the family for many years during which it has provided the sustenance of the family, whereby it has acquired an inherent affection or symbolic value. Thus, for many farmers in the Central Valleys, the maize seed lot is something they have in-trust, which links them with previous generations, and which they, in turn, must pass on to their descendants.

Finally, saving seed is strongly associated with being "a good farmer". In their own way, each of the above mentioned aspects is part of what constitutes the local concept of "a good farmer" a notion which can be said to lay out certain principles for what is considered appropriate behavior of a good farmer (Badstue *et al.*, 2003). This should not be understood in a fixed or prescriptive sense, but rather as a set of abstract guidelines open to individual interpretation and negotiation. One aspect of appropriate behavior of a "good farmer" is to take good care of his/her seed (Badstue *et al.*, 2003, 2005). As the female farmers in one of the focus groups stated: "[losing seed]... is like hurting one's pride of being a good farmer—it is like a humiliation!" On the other hand, though, as became clear during the focus group discussions and the individual interviews, it is acceptable and legitimate to obtain seed from other farmers in a bad year or for experimentation with other kinds of maize germplasm, provided one is generally thought to manage seed with appropriate care. In this case, the seed receiver has a justifiable need for the seed, and is not someone who prefers to rely on others for seed rather than make the effort of selecting and storing seed from the previous harvest. In other words, this person "deserves" the seed and will appreciate the favor.

Clearly, for farmers in the study area, selecting and saving seed is not just a question of saving money, but a decision that has cultural, economic, and agro-ecological components (Badstue *et al.*, 2005).

It should be noted that, although farmers select their own seed year after year, they may also, occasionally, substitute entirely, complement, or mix their own seed with seed from external sources. Initially a farmer may state: "I have planted this white [maize] for 20 years." However, further conversation may well reveal that on one or more occasions the seed was complemented or mixed with external seed. With regards to the study communities, these practices have also been noted by Smale *et al.* (1999) and similar practices have been reported from other regions in Mexico (Aguirre Gómez, 1999; Louette *et al.*, 1997). Over time, these and other management practices, for example, how the farmer selects seed, as well as naturally occurring pollen flow [6] from other farmers' maize fields, may well change the genetic make-up of his/her maize.

5. SEED EXCHANGE

Although saving seed from one's own harvest is the backbone of local seed supply in the study area, farmers do acquire seed from other sources from time to time.

The quantity of seed involved in farmer-to-farmer seed transactions is often quite small (Table 2). Seed quantities were recorded in 386 transactions in the tracer study. While the average quantity was 12.5 kg, half of these transactions involved only 8 kg or less. In the CIMMYT/INIFAP research project, 2,726 kg of seed of diverse maize varieties were sold to a total of 371 farmers, and the average quantity

Table 2. *Quantity of seed involved in transactions*

Seed quantity per transaction kg[a]	No. of transactions	%
⩽4	100	25.9
5–8	93	24.1
9–12	59	15.3
13–16	43	11.1
17–20	42	10.9
21–40	45	11.7
41–48	4	1.0
Total	386	100

[a] Unknown for 130 of the 516 transactions.

purchased was 4.3 kg (Bellon, 2004). In comparison, farmers in the region normally calculate four almudes [7] of seed, approximately 16 kg, to plant 1 ha maize. In spite of the fact, that most plots are very small in the Central Valleys and therefore seldom require large amounts of seed, the high percentage of seed transactions involving small quantities of seed suggests that a considerable part of all seed flows are motivated by elements of farmer experimentation, or take place to complete the required amount of seed in the event of partial seed loss.

It is difficult to assess the frequency of seed transactions. Farmers do not keep records of such transactions, and estimates must rely on the memory of those interviewed. In the tracer study, seed transactions involving current cultivars were registered, noting the year they took place and allowing farmers to go as far back in time as desired. Findings indicated that recent transactions are more likely to be remembered than those from the distant past. Notwithstanding these limitations, an estimate of the frequency of seed transactions was calculated for the three most recent years and showed that on average acquisitions occur 0.31 times per year per farmer and distributions 0.39 times per year per farmer—in both cases, approximately once every three years (Badstue *et al.*, 2006). In 2001 only 24.2% and 20.9% of farmers in the tracer study engaged in seed acquisitions and distributions, respectively. In summary, seed transactions are relatively infrequent and do not involve a large number of farmers every year.

(a) *Embedded seed transactions*

A seed transaction is an economic practice where a good is exchanged between two parties. Several authors have argued that actors' purposive behavior is embedded in concrete contexts, including systems of social relations, and therefore should be analyzed as such (Gudeman, 2001; Long, 2001; Swedberg & Granovetter, 2001).

In a recent paper Granovetter points out why social structure should be regarded as an important influence on economic outcomes (Granovetter, 2005). First of all, social networks affect the flow and the quality of information to a significant degree. At the same time they constitute an important source of reward and punishment, which often has a bigger impact when coming from others personally known and whose acceptance we seek. Finally, Granovetter notes, that where trust emerges, it does so in the context of a social network.

The presence of trust can provide a more secure environment for transactions and social exchange, as demonstrated, for example, by DiMaggio and Louch (1998) in a study of people's use of networks in relation to a certain range of consumer transactions. The authors conclude that uncertainty about product characteristics or performance quality leads people to prefer sellers with whom they have noncommercial ties. This is effective, they argue, because it embeds commercial exchanges in a web of obligations and holds the seller's network hostage to appropriate role performance in the economic transaction. Also of interest here, is their point that exchange frequency reduces the extent of within-network exchanges—that is, more common in not-so-frequent acquisitions/transactions. Farmers obtained seed from many types of seed providers (e.g., family members, *compadres*, [8] neighbors, friends, acquaintances, strangers, and others). In general, the large majority of seed transactions take place between people who know each other prior to the seed transaction, and who often share a feeling of social obligation toward each other (e.g., family members alone made up 47.5% of seed providers in the seed flow tracer study).

Particular types of transaction are not restricted to any one category of seed providers. Nevertheless, it appears that close social relations between the seed provider and receiver improve the latter's chances of preferential treatment, for example, in the type of transaction or with regards to its terms or rates (Badstue *et al.*, 2003). The transactions that mediate seed flows between farmers in the study communities, and the social relations associated with them, have been thoroughly analyzed (Badstue *et al.*, 2006).

Trust is a key issue in seed transactions (Almekinders *et al.*, 1994; Seboka & Deressa, 2000). This is directly related to the lack of transparency of seed. In addition, farmers pointed out, that they generally prefer seed providers who are easy to approach and believed to be willing to grant one's request, especially if one cannot pay for the seed with money and therefore depends on negotiating another type of transaction. Finally, the trustworthiness of the seed receiver is relevant to seed providers, for example, with regards to the types of seed transactions that involve "payment" forms other than money, and where the seed provider depends on the seed receiver upholding his/her part of the deal.

Additional research on farmers' seed acquisition strategies in the study area, indicates the significance of differences in farmers' trust in seed providers: Seed acquired from people the farmer knows and trusts is generally perceived as entailing less risk of crop failure due to inadequate seed, than seed acquired from unknown or impersonal sources, such as market vendors or commercial seed traders (Badstue, 2004). In other words, the more the seed receiver knows and trusts the seed provider, the less the perceived risk or uncertainty related to incomplete or incorrect information.

Finally, relations of trust are conducive to easy access to trustworthy information at low costs. Farmers may already know the characteristics of varieties used by kin or close friends, and they can easily obtain more information (Badstue, 2004; Badstue *et al.*, 2006). Thus, in accordance with DiMaggio and Louch (1998) findings mentioned above, acquiring seed from social relations of trust can be seen as a way of reducing the problem of lack of transparency in seed. This, in turn, helps reduce farmers' transaction costs in relation to seed acquisition to a minimum (Badstue, 2004).

(b) *Reasons for acquiring seed*

Farmers reasons for acquiring seed were identified and described during the focus group discussions and in-depth interviews with key informants, and were later quantified during the tracer study. Based on farmers' own classifications, the reasons provided by the informants for acquiring maize seed from other sources can be divided into four main themes: (a) experimentation, (b) commence farming, (c) lack of sufficient seed for planting, and (d) initiative by other farmers. Grouped by these themes, Table 3 presents the distribution of informants' reasons for acquiring seed from other sources, and their percentage relative to the total number of seed acquisitions recorded in the seed flow tracer study.

Like farmers elsewhere, many farmers in the Central Valleys are curious and eager to learn and explore new options. While they may be well aware that a maize variety that works for others may not work for them, they also recognize that the maize of others may have advantages or provide traits that may be worthwhile having. Furthermore, many farmers in the study area believe that "foreign" seed can eventually "acclimatize" to local conditions, if planted and selected under those conditions. These elements lead to many instances in which farmers "try out" other materials they come across, combine them or even cross them with their own materials to "see if it works." These different farmer experiments usually involve only small quantities of seed or land, thereby minimizing the risks related to experimentation.

When new households start farming on their own account, they usually get seed from parents or other close relatives. Not surprisingly, therefore, this counts as an important reason for seed acquisition.

Lack of seed may be due to seed loss or to not being able or willing to save sufficient seed. Seed loss may occur because of low yield or total harvest loss, due to drought, water logging, insect attacks, weeds, hail, lodging, or poor management. Seed may be lost during storage due to insects or rodents. A farmer may not save seed, or at least not enough, because he or she had to sell or eat everything that was harvested including the seed set aside, as a result of insufficient production, an emergency, or a crisis. Farmers who produce maize for animal feed may harvest before seed is produced.

Table 3. *Reasons for acquiring maize seed*

Theme[a]	No.	%
Experimentation	100	32.5
Commencing to farm	86	27.9
Lack of sufficient seed	56	18.2
Other farmer's initiative	17	5.5
Others	49	15.9
Total	308	100

[a] Unknown for 18 of the 326 seed acquisitions.

Obviously, seed loss may also occur as the result of several converging factors. People, who for some reason decide not to plant maize for some time, for example, due to temporary migration, face a similar situation when they take up planting again, due to the relatively fast decline in maize seed germination rate and vigor (Morris *et al.*, 1998).

Farmers sometimes receive seed from other farmers without having asked for it, for example, when they agree to another farmers' request for a seed-for-seed exchange. Even if a farmer has not actively looked for the seed, he or she may eventually decide to plant it, although this does not always happen. Also, farmers sometimes receive small amounts of seed as gifts. For example, one farmer's sister, who lives in another town, each year, brings small amounts of seed from her own maize field, when she comes to visit. Her brother plants this seed and explains that he regards it as a token of the affection between his sister and himself and as a way to stay "close," in spite of the distance that separates them. In any case, these reasons for acquiring seed are relatively infrequent.

In many cases, seed loss appears to be associated with a certain social stigma, even though the cause for seed loss may be beyond the farmer's control. Informants explained that seed loss sometimes is associated with laziness, lack of knowledge, and inappropriate working practices, etc. Meanwhile, never to have lost one's seed is a cause for pride for many farmers. Obviously, these circumstances do not motivate people to talk about the occasions on which they may have lost their seed, and it is possible that this influenced the answers to the tracer study.

(c) *Reasons for distributing seed*

The flip side of acquiring seed is distributing it. The reasons provided by farmers for distributing seed to other farmers can be divided into two main themes: (a) to help the recipient and (b) to obtain something in return, for example, money or seed. Table 4 shows how the seed distributions recorded in the tracer study distributed across these themes.

In another paper (Badstue *et al.*, 2006), we have argued that access to seed in the study area may be conceptualized as part of a general social responsibility for mutual assistance. Most seed providers stated that they distributed seed to help the seed receiver. Linked to the notion of being a "good farmer" is the idea that one should not refuse to help a fellow farmer asking for seed if one has sufficient seed to share. As stated by various informants: "I gave him the seed because I had it!"

Table 4. *Reasons for distributing seed*

Theme[a]	No.	%
Help the recipient	131	69.3
Obtain something in return	50	26.5
Others	8	4.2
Total	189	100

[a] Unknown for 1 of the 190 seed distributions.

The other theme involves obtaining something in return for the seed, mostly cash and also seed. It is important to note that most distributions with the purpose of obtaining money were associated with only two persons who are known to sell seed every year as a way of supplementing their income. As described in the next section, most acquisitions were purchases, but relatively few seed providers were motivated exclusively by the view to obtaining money in return. This, in turn, suggests that the primary motive for farmer-to-farmer seed distribution rarely is to generate a profit. These findings suggest that there is a strong cultural value in the study area associated with being helpful to others, as long as one is able to do so while covering one's own needs. For example, people who are known to have plenty of seed, but who are nevertheless not willing to provide seed to others, are thought of as selfish. This links with data from the in-depth interviews with key informants, which showed that an important motivating factor for many seed providers is that the person requesting the seed has a genuine need for it. Finally, it should be mentioned that this seems also to be part of a common sense of reciprocity; as one of the informants pointed out: "What goes around, comes around." On the other hand, the frequency of purchase as transaction type and the above-mentioned broad willingness to supply seed to a buyer, also suggest that monetary gain could often be part of the motive for supplying seed.

6. DISCUSSION

A series of factors that influence farmers' seed supply practices have been identified. In relation to problems regarding seed supply farmers in the study area negotiate solutions on an ad hoc basis. However, considerable variation exists between farmers, even with regards to individual farmers who on different occasions may respond differently to seemingly similar problems.

The central axis of the seed system in the study communities appears to be farmers' practice of selecting and saving seed from one year to another. This is the source of seed for the large majority of maize area planted in this region, and for the individual farmer this practice can help reduce perceived risk and costs. It is of further symbolic importance for some, who take pride in being self-sufficient in seed or regard the family seed as something valuable they have in trust and must pass on to subsequent generations. In addition, the common practice of saving seed is a vital element in maintaining seed security at community level. The widespread practice of saving enough seed for the next planting, and some extra for any contingencies, provides a buffer against seed loss at the household level, and also helps ensure that, in general, seed can be obtained locally when needed.

During seed selection farmers exercise selection pressure in an attempt to enhance favored varietal traits and lessen the influence of undesired traits. Analysis of the genetic structure of maize landraces collected in the study communities has shown a strong structure associated with farmers and communities, when phenotypic traits are analyzed (Pressoir & Berthaud, 2004). Structure on phenotypic traits indicate that varieties collected from the same farmer or same community are more similar in their characteristics—mainly ear and grain traits—than those that were collected from other farmers or other villages. This indicates that human selection is playing a key role in creating and maintaining different types of maize, and hence, phenotypic diversity (Perales *et al.*, 2005; Pressoir & Berthaud, 2004).

The problem of nontransparency of seed and the issue of genotype-by-environment interaction entails certain fundamental problems, which mean that acquiring maize seed is not a trivial transaction.

In most cases farmers' easiest source of knowledge and trustworthy information about maize and maize seed, as well as their preferred source of seed, is people they know and trust, who in many cases also farm in the same community. Furthermore, acquiring seed from another farmer from the same community has the advantage that one knows the seed was produced in that community, and therefore is likely to be adapted to local agro-ecological conditions. Even if environmental conditions vary within the same community, in most cases, the farmer would easily be able to determine the likelihood that the seed will be adapted to the conditions of his/her own land.

Finally, using social networks to acquire seed is effective because it embeds the seed transactions in a web of obligations and, as pointed out by DiMaggio and Louch (1998), "holds the seller's network hostage to appropriate role performance." Thus, acquiring seed via one's social network can be seen as a way of reducing the risk of planting inappropriate seed, that is, maize that does not correspond to one's production or consumption objectives, or which is not adapted to the local environmental conditions.

The notion of the "good farmer" may also come into play in relation to maize seed transactions. As mentioned above, it is thought appropriate "good-farmer-behavior" to help other farmers in need, when possible and within reason. In as far as a farmer can spare the seed, this includes acting as seed provider on the request of other farmers who need seed. This sense of social responsibility linked to the notion of "a good farmer" may well be triggered when a request for seed is brought forward. Meanwhile, failing to save seed is sometimes associated with a certain disgrace or loss of prestige. While this may play a role as an incentive for farmers to live up to this standard, it may also play a role in reducing the problem of free riders. [9]

The practices and dynamics that make-up the local seed system in the study area appear to be grounded in a set of shared views and conditions, which in themselves are based on the agro-ecological, cultural, and social environments in which these farmers operate. Local seed supply in these communities is not based primarily on commercial motives. It is mainly part of a moral system based on trust and social responsibility.

It should be mentioned that once in a while a farmer may acquire seed at the regional market or elsewhere outside the community in order to deliberately avoid the various implications that may arise from acquiring seed from other farmers in the community; such as expectations of reciprocity and the feeling of "indebtedness," the "stigma" of having lost seed, etc. Likewise, it should be noted, that while the types of transactions not involving money payments may be attractive under some circumstances, under other circumstances a farmer may find that paying for the seed with money can provide a swift and less personal option, and thus be preferable.

When acquiring maize seed from a stranger, for example, at a regional market place, there are no means of knowing its genotype-by-environment adaptation or other characteristics apart from what the vendor claims. As several farmers exclaimed when referring to commercial traders: "They just want to sell their goods!" In general, acquiring seed from unknown sources is perceived by farmers as entailing a certain risk of acquiring inappropriate seed (Badstue, 2004).

Recognizing that other maize varieties may be useful or contain desirable characteristics, farmers experiment with and "try out" seed of other kinds of maize than their own. This allows farmers to see for themselves the traits and performance of the maize variety in question and judge whether it is appropriate for their individual needs and preferences. Meanwhile, farmers in the study communities do not associate small-scale experimentation with significant costs, for example, in terms of extra time or labor (Badstue, 2004). The principal cost is the risk that the experiment will not be successful. However, this is manageable due to the small scale of most farmer experiments, which reduce the risk of major crop failure. Farmer experiments therefore serve both the purpose of information and of risk control. In addition these experiments are also used to multiply seed. If the farmer decides to incorporate the "new" varieties into the household's maize repertoire, or alternatively mix it with seed of their own varieties in order to create new, desirable combinations, they may therefore not need to acquire seed again.

Pressoir and Berthaud's (2004) research on the genetic structure of landraces collected in the same study communities has shown absence of structure in these populations when neutral markers are analyzed. By definition neutral markers are not under selection. They provide information on the evolutionary history of a population, that is, migration, bottlenecks, drift. The fact that no structure was found indicates that migration (gene flow) among these populations has been strong enough to compensate for the effects of bottlenecks and drift.

The results on genetic diversity complement the present analysis of the seed system in the study area. Farmers' practice of saving and selecting seed both constitutes the basis of the phenotypic diversity observed in the study area and the foundation of the seed system. One could say that each farmer is creating and maintaining his/her own unique maize varieties. Second, gene flow is important to bring new traits and modify varieties to fit farmers' needs—as farmers do when they experiment with "foreign" seeds and mix them with their own. Third, gene flow may also be important to maintain the viability of these landraces in the face of deleterious mutations, or simply to avoid inbreeding depression. The current seed system allows farmers to continue this process of experimentation and incorporation of new varieties or traits into their repertoire.

Given the limited, relative frequency of seed loss in the study area, farmers current seed supply practices appear relatively efficient in terms of maintaining local crop genetic resource diversity. While the system depends on sufficient opportunities for obtaining seed from others when the need arises, at the moment this does not appear to be a major limitation. From a population genetic point of view the seed system appears to work well and be efficient in continuing to maintain a diversity of maize landraces and contribute to the conservation of maize genetic diversity (Bellon *et al.*, 2003; Smale *et al.*, 2003).

7. CONCLUSIONS

In this paper we have presented an analysis of the dynamics of smallholders' maize seed supply practices in the Central Valleys of Oaxaca. The core principle of the local seed system in the study area is farmers' reliance on selecting and saving seed from the previous harvest. Farmer-to-farmer seed flow is an occasional event, which mostly involves relatively small quantities of seed, yet, it remains an essential element of the seed system in order to ensure local seed security and maintain local maize genetic diversity.

Even though farmers in the study communities live and farm under seemingly similar conditions, individual preferences, production conditions, and production objectives may vary considerably from one farming household to another. In this context, farmers' widely observed practice of selecting and saving seed from the previous harvest provides the basis for a pool of considerably diverse and locally adapted maize varieties. Furthermore, at any one time the number of farmers in need of, or requesting seed from others, is relatively limited. This, in turn, makes it relatively easy for these farmers to find someone who can provide the seed they need at a relatively low cost and risk.

In combination with the occasional introduction of new maize genetic material from other farmers or elsewhere, the on-farm reproduction and selection of seed of preferred varieties provides a relatively efficient basis for the maintenance of local maize genetic diversity. Whereas no imminent threat to maize genetic diversity in the study area was identified in the research referred to here, the important role of gene flow in preserving the viability of farmer varieties in the area was pointed out.

Furthermore, the current seed system provides a relatively secure seed supply of a range of valued farmer varieties. However, as mentioned, the farming systems in the study area are characterized by low productivity and maize production per area is low. The use of improved seed could be one option for increasing maize productivity. It is possible that this could help farmers produce sufficient maize on less land, thereby freeing up land for other, more income generating, purposes, or for increased maize production.

Finally, the current seed system is efficient in supplying farmers with maize seed of varieties that correspond well to local consumption and production objectives, and which are able to perform under local agro-ecological conditions. In the few cases where improved varieties are used in the study communities it is mainly for corn-on-the-cob and feed production, not for the production of grain for consumption. This suggests that the improved varieties available in the study area may be considered to have inferior consumption characteristics from the point of view of the local population.

8. IMPLICATIONS FOR POLICY CONSIDERATIONS

From a policy point of view, the analysis of the dynamics of farmers' maize seed supply practices in the Central Valleys of Oaxaca raises several relevant issues. Findings point to both challenges and opportunities and may be relevant in a broader perspective, for example, in relation to commercial seed sector development in this area of Mexico, or for other initiatives related to introduction of improved varieties.

The importance of farmer demand for different maize types should be considered and the germplasm involved should be assessed in relation to local production and consumption preferences, as well as local production conditions.

Farmers demand for seed of other varieties is relatively infrequent, and mostly involve relatively small amounts of seed. Under these circumstances supplying seed may not be a profitable enterprise. Interventions such as those practiced in the CIMMYT/INIFAP research project demonstrated farmers' interest in acquiring seed of other maize varieties. However, the average quantity of seed per acquisition was just 4.3 kg, which may not be a problem if the demand is only for one or two varieties. However, if the demand is for many different varieties, the costs of producing, managing, and selling seed may be too high for a commercial provider, since commercial seed enterprises most likely have to supply larger quantities of fewer varieties to be financially viable.

Maize continues to play an important role in the study area with regards to food security. While farmers in these communities are often curious and interested in trying out new things, in many cases, they are also concerned about risks in relation to their maize production. Unstable seed supply, timeliness of seed supply, higher costs of improved seed—in the study area approximately 5–7 times the cost of farmer saved seed—all add to the more generic problem of nontransparency of seed, and can influence and maybe hamper the adoption process. Under such circumstances one may likely expect farmers first to experiment for some time with small quantities of seed, before deciding whether or not to adopt. Emphasis should therefore be on medium to long-term interventions.

Farmer skepticism with regards to the trustworthiness of market traders and commercial seed vendors relates to information quality about seed traits and quality. However, it seems reasonable to think that it would also relate to additional aspects such as the stability, reliability, and timeliness of seed supply. Obviously, improving confidence in commercial seed traders presents a challenge.

To a large extent many of these challenges lead back to the fundamental problem of nontransparency of seed, and to the importance of trustworthy information about maize seed of different varieties. Identifying ways of conveying the relevant information to the users of the seed in a straight-forward and trustworthy way would seem a useful contribution in this regard.

Despite a strong concern for risk avoidance, farmer interest in and willingness to experiment and learn about new and different maize varieties, presents an opportunity for the introduction of improved varieties. Though this experimentation mostly involves small quantities of seed, it nevertheless presents a window of opportunity for anyone who would like to introduce alternative maize germplasm.

Many farmers in the study communities express an attitude of generalized trust in other farmers, and farmer-to-farmer information flows can play an important role in relation to the spread of information regarding innovations and new technologies (e.g., Ryan & Gross, 1943). This may also be regarded as an opportunity in relation to the introduction of improved varieties, and can be used actively. The concept of ''farmer–dealers'' was, for example, an important element in the spread of hybrid maize in the US (Duvick, 1998). By using local farmers as their agents, seed companies and government extension promoted their products through local channels that farmers felt comfortable with and could easily relate to.

In the study reported on here, no specialized seed-focused institutions of collective action were identified. Rather than maintaining specialized networks for seed needs, which occur relatively infrequent, farmers tend to ''piggyback'' seed needs on other networks of social relations on an ad hoc basis. The problem of nontransparency of seed is one of the factors, which may influence the decision to transact with a friend or a relative, as a response to the perceived risk or uncertainty this fosters. Under these circumstances, development interventions at the community level, whether directed toward conservation or introduction of improved seed, should focus on existing social organizations rather than trying to create new organizations dedicated to seed supply.

Finally, in relation to the conservation of crop genetic diversity on-farm, the study points to the importance of sustaining seed flows between farmers. In this regard, seed fairs and other interventions that promote knowledge-based information flows and access to ''new'' interesting varieties for experimentation at low cost and low risk, represent interesting options.

NOTES

1. By seed system we refer to the set of sources of seed and related information, practices and transactional arrangements on which farmers rely to obtain seed for agricultural production.

2. In another very illustrating example of this, Perales, Benz, and Brush (2005) have shown that ethnolinguistic differences between ethnic groups in Chiapas could explain the morphological and agricultural differences found between varieties, while neutral markers showed no genetic differentiation. This means that genetic exchanges, that is, gene flow, had been sufficient over time to eliminate genetic differentiation.

3. The analysis presented here draws on findings from three different but interrelated research projects carried out in the same area of the Central Valleys of Oaxaca, Mexico. The major part of this paper is based on a project which examined the role of collective action in the conservation of maize genetic diversity on-farm (Badstue *et al.*, 2005). In addition, the paper draws on another study focusing on the identification of farmers' transaction costs in relation to seed acquisition (Badstue, 2004). Both of these research projects built on previous research undertaken by the International Maize and Wheat Improvement Center (CIMMYT) and Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP) during 1997–2002 in the same region (Bellon *et al.*, 2003; Smale, Aguirre, Bellon, Mendoza, & Manuel Rosas, 1999).

4. A Microsoft Access database was used for managing the data.

5. For more on genotype-by-environment interaction, see for example, Bänziger and Cooper (2001).

6. As an open-pollinated crop, maize is subject to cross-pollination (Morris, 1999).

7. An almud is a commonly used volume measurement for grain or seed in the Central Valleys (Smale *et al.*, 1999). One almud of maize is approximately 4 kg.

8. From the word *compadrazgo*, referring to a ritual kinship, somewhat similar to the relation known elsewhere as godparents, through which close relations of loyalty, mutual help, reciprocity, and confidence are established and formalized (Cordero Avendaño de Durand, 1997).

9. The fact that failing to save seed is associated with a certain loss of prestige may deter certain persons from just asking others for seed instead of going through the trouble themselves of selecting and saving seed.

REFERENCES

Aguirre Gómez, J. A. (1999). Análisis regional de la diversidad del maíz en el Sureste de Guanajuato. PhD disertación. Universidad Nacional Autónoma de México, México, DF.

Almekinders, C. (2001). *Management of crop genetic diversity at community level*. Germany, GTZ: Eschborn.

Almekinders, C., & de Boef, W. (2000). *Encouraging diversity: The conservation and development of plant genetic resources*. London: Intermediate Publications Ltd.

Almekinders, C. J. M., Louwaars, N. P., & de Bruijn, G. H. (1994). Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica, 78*(3), 207–216.

Badstue, L. B. (2004). Identifying the factors that influence small-scale farmers' transaction costs in relation to seed acquisition. An ethnographic case study of maize growing smallholders in the Central Valleys of Oaxaca, Mexico. ESA Working Paper No. 04-16. Rome: Food and Agriculture Organization of the United Nations (FAO).

Badstue, L. B., Bellon, M. R., Berthaud, J., Juárez, X., Manuel Rosas, I., & Solano, A. M. (2006). Examining the role of collective action in an informal seed system: A case study from the Central Valleys of Oaxaca, Mexico. *Human Ecology, 34*(2), 249–273.

Badstue, L. B., Bellon, M. R., Berthaud, J., Ramirez, A., Flores, D., & Juarez, X. (2005). Collective action for the conservation of on-farm genetic diversity in a center of crop diversity: An assessment of the role of traditional farmer's networks. CAPRI Working Paper, no. 38. Washington: International Food Policy Research Institute (IFPRI).

Badstue, L. B., Bellon, M. R., Juárez, X., Manuel Rosas, I., & Solano, A. M. (2003). Social relations and seed transactions among small-scale maize farmers: A case study from the Central Valleys of Oaxaca, Mexico. Economics Working Paper 02–02. Mexico City: International Maize and Wheat Improvement Center (CIMMYT).

Bänziger, M., & Cooper, M. (2001). Breeding for low input conditions and consequences for participatory plant breeding: Examples from tropical maize and wheat. *Euphytica, 122*(3), 503–519.

Bellon, M. (2004). Conceptualizing interventions to support on-farm genetic resource conservation. *World Development, 32*(1), 159–172.

Bellon, M., Berthaud, J., Smale, M., Aguirre, J. A., Taba, S., & Aragón, F. (2003). Participatory landrace selection for on farm conservation: An example from the Central Valleys of Oaxaca, Mexico. *Genetic Resources and Crop Evolution, 50*(4), 401–416.

Bellon, M., & Brush, S. B. (1994). Keepers of maize in Chiapas, Mexico. *Economic Botany, 48*(2), 196–209.

Cordero Avendaño de Durand, C. (1997). *La vara de mando. Costumbre jurídica en la transmisión de poderes*. Oaxaca de Juárez, México: Biblioteca del 465 Aniversario.

Cromwell, E. (1990). Seed diffusion mechanisms in small farmer communities: Lessons from Asia, Africa, and Latin America. ODI Network Paper 21. London: Overseas Development Institute.

DiMaggio, P., & Louch, H. (1998). Socially embedded consumer transactions: For what kinds of purchases do people most often use networks? *American Sociological Review, 63*(5), 619–637.

Duvick, D. N. (1998). The United States. In M. Morris (Ed.), *Maize seed industries in developing countries* (pp. 193–212). Boulder, CO: Lynne Rienner.

Granovetter, M. (2005). The impact of social structure on economic outcomes. *Journal of Economic Perspectives, 19*(1), 33–50.

Gudeman, S. (2001). *The Anthropology of Economy*. Oxford: Blackwell Publishing Ltd.

Hernandez, E. (1985). Maize and man in the greater Southwest. *Economic Botany, 39*(4), 416–430.

INEGI (Instituto Nacional de Estadística, Geografía e Informática) (2001a). XII Censo General de Población y Vivienda 2000. Mexico: INEGI.

INEGI (Instituto Nacional de Estadística, Geografía e Informática) (2001b). Aspectos Geográficos de Oaxaca. Mapa de Temperatura Media Anual. <http://oax.inegi.gob.mx/territorio/espanol/temperat.html> (last update: 29/03/2001, 13:04).

Jarvis, D. I., Myer, L., Klemick, H., Guarino, L., Smale, M., Brown, A. H. D., *et al.* (2000). *A training guide for in-situ conservation on-farm. Version 1*. Rome: International Plant Genetic Resources Institute (IPGRI).

Long, N. (2001). *Development sociology. Actor perspectives*. London: Routledge.

Louette, D., Charrier, A., & Berthaud, J. (1997). In situ conservation of maize in Mexico: Genetic diversity and maize seed management in a traditional community. *Economic Botany, 51*(1), 20–38.

Matsuoka, Y., Vigouroux, Y., Goodman, M. M., Sanchez, J., Buckler, G. E., & Doebley, J. (2002). A single domestication for maize shown by multilocus microsatellite genotyping. *Proceedings of the National Academy of Sciences, 99*(9), 6080–6084.

Morris, M. (1999). Maize in the developing world: Waiting for a green revolution. In M. Morris (Ed.), *Maize seed industries in developing countries* (pp. 35–54). Boulder, CO: Lynne Rienner.

Morris, M., & López-Pereira, M. A. (1999). *Impacts of maize breeding research in Latin America 1966–1997*. Mexico, DF: International Maize and Wheat Improvement Center (CIMMYT).

Morris, M., Rusike, J., & Smale, M. (1998). Maize seed industries: A conceptual framework. In M. Morris (Ed.), *Maize seed industries in developing countries* (pp. 35–54). Boulder, CO: Lynne Rienner.

Orlove, B. S., & Brush, S. B. (1996). Anthropology and the conservation of biodiversity. *Annual Review of Anthropology, 25*, 329–352.

Perales, H. R., Benz, B. F., & Brush, S. B. (2005). Maize diversity and ethnolinguistic diversity in Chiapas, Mexico. *Proceedings of the National Academy of Sciences, 102*(3), 949–954.

Perales-Rivera, H. R., Brush, S. B., & Qualset, C. (2003). Dynamic management of maize landraces in central Mexico. *Economic Botany, 57*(1), 21–34.

Piperno, D. R., & Flannery, K. V. (2001). The earliest archaeological maize (*Zea mays* L.) from highland Mexico: New accelerator mass spectrometry dates and their implications. *Proceedings of the National Academy of Sciences, 98*(4), 2101–2103.

Pressoir, G., & Berthaud, J. (2004). Population structure and strong divergent selection shape phenotypic diversification in maize landraces. *Heredity, 92*(2), 95–101.

Ryan, B., & Gross, N. C. (1943). The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology, 8*(1–4), 15–24.

Sanchez, J. J. G., Goodman, M. M., & Stuber, C. W. (2000). Isoenzymatic and morphological diversity in the races of maize in Mexico. *Economic Botany, 54*(1), 43–59.

Seboka, B., & Deressa, A. (2000). Validating farmers' indigenous social networks for local seed supply in Central Rift Valley of Ethiopia. *Journal of Agricultural Education and Extension, 6*(4), 245–254.

Smale, M., Aguirre, A., Bellon, M., Mendoza, J., & Manuel Rosas, I. (1999). Farmer management of maize diversity in the Central Valleys of Oaxaca, Mexico: CIMMYT-INIFAP. 1998 Baseline socioeconomic survey. CIMMYT Economics Working Paper 99-09. International Maize and Wheat Improvement Center (CIMMYT), Mexico DF.

Smale, M., Bellon, M., Aguirre, A., Rosas, I. M., Mendoza, J., Solano, A. M., *et al.* (2003). The economic costs and benefits of a participatory project to conserve maize landraces on farms in Oaxaca, Mexico. *Agricultural Economics, 29*(3), 265–275.

Sperling, L., Heidegger, U., & Buruchara, R. (1995). Enhancing small farm seed systems: Principles derived from bean research in The Great Lakes Region. Network on Bean Research in Africa, Occasional Publications Series, No. 15, Cali: International Centre for Tropical Agriculture (CIAT).

Subedi, A., Chaudhary, P., & Sthapit, B. (2003). Maintaining crop genetic diversity on-farm through farmers' networks. In *CIP-UPWARD: Conservation and sustainable use of agricultural biodiversity: A sourcebook* (pp. 259–265). Philippines: International Potato Center and Users' Perspectives With Agricultural Research and Development (UPWARD).

Swedberg, R., & Granovetter, M. (2001). Introduction to the second edition. In M. Granovetter, & R. Swedberg (Eds.), *The sociology of economic life* (pp. 1–30). Boulder: Westview Press.

Thiele, G. (1999). Informal potato seed systems in the Andes: Why are they important and what should we do with them? *World Development, 27*(1), 83–99.