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Collective Action for the Conservation of On-Farm Genetic Diversity in a Center of Crop Diversity: An Assessment of the Role of Traditional Farmers' Networks

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ABSTRACT

This project explored the possible role of collective action among small-scale farmers in managing and maintaining genetic resources in a center of crop diversity. It focused on the local institutions that ensure the supply of seed of diverse maize landraces to small-scale farmers in the Central Valleys of Oaxaca, Mexico. The key hypothesis was that the medium-to-long-term supply of a diverse set of varieties to any individual small-scale maize farmer depends on an agreement among a group of farmers to manage and supply the seed of these landraces to each other, if the need arises, and that this constitutes a form of collective action. Six communities were studied, three of them in-depth. Methodologies used included in-depth semi-structured interviews with key informants, focus group discussions, and a tracer study—following the flows of seed among different farmers. The results show that, while there is a well-developed local seed supply system based on sets of social relationships and involving multiple types of transactions, there is no evidence of collective action. Most farmers rely on and prefer to select and save seed from their own harvests. There are seed flows, however, and most seed transactions take place among people with social links, but not within a well-defined group. There are no specialized suppliers of seed, either individuals or groups. Most transactions are bilateral and while the most common transaction is the sale and purchase of seed, this is not done for profit but out of a sense of moral obligation. The system is based on the creation of trust, which is needed because seed is not transparent—that is, it is not possible to fully predict the plant phenotype that may result from a given seed simply by looking at the seed. Farmers demand different types of maize and they believe that there is a strong genotype-by-environment interaction, hence "foreign" maize types may not be appropriate for them. At the same time, farmers also find occasional experimentation beneficial and believe that they can slowly modify the characteristics of "foreign" landraces. In this system, there are strong incentives to be conservative, but also to try new landraces and experiment. The local seed system of these farmers is resilient but able to innovate as well. Interventions to support the conservation of landraces on farm, based on specialized networks for seed that rely on collective action, may not work.

Keywords: maize, small-scale farmers, informal seed systems, genetic resources, Mexico, collective action

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1. INTRODUCTION

The research presented here focuses on the local institutions that ensure the supply of seed of a diverse array of farmer varieties[5] to small-scale farmers in centers of crop diversity—in this case, maize in the Central Valleys of Oaxaca, Mexico. The project addressed the following question: What is the role of collective action among small-scale farmers in managing and maintaining genetic resources in a center of crop diversity?

This paper describes and analyzes the seed system that ensures the supply of a diverse array of farmer varieties to small-scale maize farmers in the Central Valleys of Oaxaca—an area of significant crop diversity. By seed system we refer to the set of sources of seed, ways of getting it, social relations and rules on which farmers rely to obtain seed for agricultural production. The original hypothesis was that individual farmers would have strong incentives to participate in specialized and organized collective action to ensure their access to a larger base of maize genetic diversity than they would be able to manage individually.

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[5] *Farmer varieties* (referred to as "varieties" in this manuscript) are the crop populations that a group of farmers recognize as distinct units. They may not have specific names beyond the color of the kernel, i.e. a farmer may plant two varieties of white maize. A farmer variety is not a variety in the sense of commercial agriculture, where a variety should be distinct, uniform and stable.

Maize agriculture in the Central Valleys of Oaxaca continues to play a significant role in farmers' livelihoods and food security. Farmers in this region value their landraces and continue to plant them, and by doing so they contribute to the conservation of maize biodiversity. A formal seed sector has yet to develop in this region, and most farmers therefore continue to produce their own maize seed year after year. However, maize farmers in the study area occasionally acquire seed from other sources, mostly other farmers, either because of seed loss due to climatic or storage problems or because they want to try out or work with other kinds of maize. These farmers have different needs and require seed of diverse landraces with multiple traits in particular combinations. When a farmer wants to acquire seed from other sources, it can be difficult to find seed that meets his requirements. First, the farmer has to find out who grows what maize variety and investigate the characteristics and performance of the maize of interest. Then he must make sure that the information offered is trustworthy and the seed is reliable, and finally, the conditions of the transaction must be negotiated with the supplying farmer. Acquiring seed of diverse maize varieties under these conditions can entail risks and high transaction costs to individual farmers.

Collective action has been defined as: "action taken by a group (either directly or on its behalf through an organisation) in pursuit of members' perceived shared interest." (Marshall 1998 cited by Knox et al. 1998). The concept of collective action has been widely used to describe and analyze the management of certain natural resources, such as forests, fisheries, and irrigation systems (Knox et al. 1998; Ostrom 1990), but to our knowledge it has not been applied to try to understand the way informal seed systems operate. As pointed out above, acquiring seed of diverse maize varieties can be difficult

and risky for individual small-scale farmers in the Central Valleys of Oaxaca. By contrast, in theory a group of farmers could maintain more diversity than any individual can, and at a lower cost and reduced probability of loss. Therefore, there should be clear incentives for individual farmers to cooperate with each other to provide seed and information for a diverse set of maize varieties. Individual farmers may rely on building and maintaining networks that allow them to manage and reduce the transaction costs associated with accessing seed. If true, these farmer networks can be seen as a form of collective action.

To test our hypothesis, we developed the following operational definition of collective action in seed transactions: *the actions of a well-defined group of farmers linked by a set of rights and responsibilities regarding the mutual supply of seed of a diverse set of farmer varieties.* Based on this definition, the following predictions were developed to examine the hypothesis.

- The adherence to a certain set of rights and responsibilities regarding the mutual supply of seed would be reflected in the way that seed transactions are carried out; i.e. certain rules or prescribed practices would be present.
- A "well-defined group of farmers" would mean that the collective action would be reflected in the social relation between the people involved, and that they should be able to identify clearly who other participants are.
- The existence of collective action would depend on its providing certain advantages over farmers working individually. These could include lower transaction costs for acquiring seed or reduced risk of seed shortages.

Understanding how these networks operate is important for several reasons. First, without seed there is no agriculture. Second, under the conditions of smallholders in the Central Valleys of Oaxaca, they depend almost exclusively on themselves and other farmers to obtain seed of preferred varieties. Third, obtaining seed of diverse varieties

under the conditions faced by these farmers can be difficult and entail high transaction costs. Fourth, the on-farm conservation and evolution of the landraces depend on farmers continuing to plant those landraces, which in turns depends on farmers having continuous access their seed.

The research described in this paper builds on another research project undertaken by the International Maize and Wheat Improvement Center (CIMMYT) and Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP) in the same region (Smale et al. 1999; Aguirre et al. 2002; Bellon et al. 2003). The aim of that research (1997–2002) was to determine the possibility of improving maize productivity while maintaining genetic diversity. This paper increases the scope of the 1997 study by examining the social arrangements that shape the seed and information flows on which farmers depend.

2. BACKGROUND

Seed supply is a fundamental element in agriculture—without seed, there is no agriculture. Unlike farmers in the developed world or commercial farmers in the developing world, small scale-farmers in the developing world who produce for self-consumption usually depend mostly on themselves for seed. Informal seed systems are still the prevailing source of seed in developing countries and many studies have stressed their importance (Cromwell 1990; Almekinders et al. 1994; Wierema et al. 1994; Sperling et al. 1995; Friis-Hansen 1999; Thiele 1999; Almekinders and Louwaars 2000; Seboka and Deressa 2000; Tripp 2001). Nevertheless, relatively little is known about how these systems function and 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." As several authors have pointed out, 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 and Deressa 2000; Tripp 2000).

An important research topic in the management and conservation of crop genetic resources has been the focus on seed as an important source of germplasm and the conservation of crop genetic diversity (Brush 1986; Boef et al. 1993; Orlove and Brush 1996; Meng and Brush 1998; Almekinders and Boef 2000; Jarvis et al. 2000; Almekinders 2001; Bellon 2004). In general, studies on these aspects at the local level often portray small-scale farmers as the caretakers of important crop genetic resources, a role they fulfill by maintaining and growing diverse varieties. However, most small-scale farmers do not maintain crop genetic resources merely for the sake of conservation. Rather, it appears that many farmers give social value to local resources and make special use of diverse crop varieties. In many cases decisions regarding varietal choice depend on multiple considerations, not just on yield. As Orlove and Brush (1996) point out such issues can be illuminated by in-depth, qualitative studies.

Informal seed systems are central to conserving maize genetic diversity, sustaining farmers' livelihoods and food security, and making small-scale agriculture a productive and viable option. Mexico is a center of domestication and diversity for maize (Matsuoka et al. 2002; Piperno and Flannery 2001; Sanchez et al. 2000a, b), and small-scale farmers continue to play a key role in the maintenance of this diversity (Bellon 2004; Hernandez 1985; Perales et al. 2003). The structure and evolution of maize genetic

diversity depend on farmers' access to a diverse array of farmer varieties. This in turn derives from the informal flow of varieties and seeds among households and communities (Bellon et al. 1997; Louette et al. 1997). An estimated 80% of the area planted to maize in Mexico is under seed selected from the previous harvest by farmers (Morris and López Pereira 1999), and thereby part of informal seed systems. To address the growing concern for the loss of crop genetic diversity and the importance of conserving genetic resources in situ, we need to know more about these systems. (Bellon 2004).

3. STUDY SITES AND METHODOLOGY

The study was carried out in six communities in the Central Valleys of Oaxaca: San Pablo Huitzo, Santo Tomás Mazaltepec, San Lorenzo Albarradas, San Agustín Amatengo, and Santa Ana Zegache. Yearly mean temperature in the region is 18-22 °C, with an average annual precipitation of 600–1,000 mm (INEGI 2001a). The rainy season runs from May to October. Maize, beans, and squash are the common crops and average farm size in the study area is 3.5 ha (Smale et al. 1999). Farming systems in all six communities are characterized by low productivity (Smale et al. 1999).

The state of Oaxaca is divided into districts and municipalities. Five of the six communities constitute municipalities headed by a municipal president and a body of counselors. One community, Valdeflores, has the status of *agencia*—an administrative unit below the municipality level—and belongs to the municipality of Zimatlan. All six communities have electricity and potable water, some medical services, and a primary school. San Pablo Huitzo, Valdeflores, San Agustin Amatengo and Santo Tomás

Mazaltepec have secondary schools, and Santa Ana Zegache and San Lorenzo Albarradas each have a national secondary school program via television.

The population in the study area is predominantly Spanish-speaking, but in Santa Ana Zegache and Santo Tomás Mazaltepec much of the population (>30%) belongs to the Zapotec ethnic group and speaks Zapotec as a first language, although in both communities almost all Zapotec speakers also speak Spanish (only 1.3% and 0.9% respectively do not; INEGI 2001b).

Maize is the major crop, being sown on 3.0 ha of the average 3.5 ha holding (Table 1).

Table 1--Key characteristics of the six studied communities

Community Characteristics	San Pablo Huitzo§	Santo Tomas Mazaltepec	San Lorenzo Albarradas§	San Agustin Amatengo	Valdeflores	Santa Ana Zegache§
Maize yield potential	Good	Poor	Poor	Poor	Good	Good
			- mean –			
Farm size 1996 (ha)	2.44+	3.91	4.01	2.84+	3.87	3.46
Maize area (ha)	1.99+	3.65	3.02	2.76+	3.55	3.22
% maize area in improved seed	0.14*	0.00	0.04	0.00	0.00	0.01
% maize area irrigated	54.2*	15.7	8.10	11.90	3.78+	0.17+
% land privately owned	49.60*	0.00	1.00	27.42*	0.00	100*
			- percent -			
Households dependent on local agricultural production	70*	100	95	98	85*	100
Households dependent on local non-farm income	40*	28	30	25	25	15*
Households dependent on remittances	3*	13*	23*	38	25	25

Source: Smale et al. (1999)

Note: * 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.

§ Communities where the seed flow tracer study took place

Farm sizes and maize area are smaller in Huitzo and Amatengo than in the other communities. Maize landraces dominate local agriculture: area planted to improved maize seed was significantly different from zero only in Huitzo, which was also the community with the highest average percentage of irrigated maize. Land tenure arrangements differ notably among communities. All farmland is privately owned in Santa Ana Zegache, whereas almost none is privately owned in Valdeflores, Mazaltepec, or San Lorenzo. In Huitzo, privately owned land represents on average about half of the

land farmed by households, and in Amatengo it represents about one quarter. Agriculture is the major source of income for nearly all households, whether located in better or poorer maize production zones. Non-farm employment is an important source of income for about one-quarter of the farmers. A similar overall percentage of households depends on remittances, although there are differences, particularly in Huitzo and Mazaltepec.

Because the CIMMYT/INFAP project was conducted in the same area, background information on all six communities was already available. The locations were selected for the contrasts they represented in maize yield potential and dependency on non-farm income (Smale et al. 1999). The information from the previous study (particularly a random sample of 240 households) was used to select the informants for this study, who in turn represented different social groups in terms of gender, age, ethnicity, economic status, and level of formal education. The research employed both qualitative and quantitative methodologies, including:

- In-depth, semi-structured ethnographic interviews with key informants to identify relevant issues and questions. This was fundamental because many issues are embedded in people's minds, practices, and institutions, and are not easily articulated by farmers, without some prior knowledge on the part of researchers that allows the identification and proper framing of effective questions.
- A series of focus group discussions in which the questions identified in the previous step were posed to groups of farmers, resulting in an inventory of responses on issues such as ways to acquire seed, reasons for doing so, social relations in seed transactions, and sources of information on the seed, among others.
- A quantitative tracer study of seed flows between farm households, based on all the information obtained in the previous two steps.

The patterns that were identified by the key informants were later confirmed by the focus groups and the tracer study. The three methods complemented each other and allowed key issues to be addressed from several angles.

The ethnographic interviews were conducted with 22 key informants from the three most contrasting of the six study communities: Santa Ana Zegache, San Lorenzo Albarradas and San Pablo Huitzo. This activity was carried out in these three communities only because of the labor intensive and time consuming character of the methodology, and because we preferred to focus our efforts on the communities with the most contrasting conditions of the six. In doing so we were able to get high quality information that sampled the range of situations present in the study area. The key informants were carefully selected based on our prior knowledge to represent contrasting socioeconomic and ethnic conditions.

There were 12 focus groups—one each for men and women in each of the 6 communities—involving 46 women and 58 men in all. The discussions covered the relative importance of seed loss among vulnerability factors that farmers face and the mechanisms that guided seed transactions. Participants also acted out seed exchanges. Focus group results were remarkably similar across communities and gender. The focus group discussions were carried out in all communities because they were easy and inexpensive to do, but they provided a great amount of valuable information.

The survey-based seed flow tracer study involved male and female representatives from 153 farm households in the same three communities where the ethnographic interviews were conducted.[6] We focused again on these three communities because the tracer study was very labor intensive and expensive. Furthermore, the results of the focus group discussions suggested that the conditions of these communities were representative of the all six. In the tracer study, we followed the flows of seed among selected farm

[6] The results of the focus group discussions provided further support for the impression that conditions in these communities fairly represented the diversity of conditions existing in all six.

households, included farmers' explanations about the transactions: why they had engaged in a transaction, with whom, and what was the significance of the transaction, among other factors. For 531 transactions we mapped incoming and outgoing flows, recording type of transaction and the social relations involved. As starting points, 10 households in each community were selected using criteria similar to those described for the selection of informants, hence this was not a random sampling. After a first round of interviews, the information gathered about other households that gave or received seed was used to include these households in a second tier of interviews, and so on until each household originally interviewed had led to an average of four additional households being covered. Because the samples were not random or independent, we present the data simply in descriptive form, with no statistical analyses.

4. RESULTS

Saving seed from one's own harvest is the normal practice in the study area. Previous research in the area showed that 89.7% of all seed lots were saved by farmers from their own previous harvest, and the rest were acquired from other farmers (Smale et al. 1999).

REASONS FOR SAVING SEED FROM ONE'S OWN HARVEST

All farmers in the study area select maize seed from their previous harvests and save it carefully for sowing the following season. The reasons for saving seed are multiple and complex, involving varied cultural, economic and agroecological components.

First and foremost is trust in one's own seed. Farmers value multiple crop traits and require varieties with different combinations of them, depending on their needs and constraints. For example, whereas most produce for self-consumption, some sell grain, others sell maize products, and others use maize to feed animals. Some farm on flat, fertile areas, while others grow maize on steep hills with shallow, infertile soils. Furthermore, farmers strongly believe that a maize variety that performs well under certain conditions will not likely do so under different ones. In other words, in their experience varieties exhibit what breeders call a high "genotype-by-environment interaction."

The above circumstances are reflected in seed selection. Farmers choose maize seed according to criteria or characteristics that they perceive as favorable for their particular needs, and they also know the performance of the plants from which the seed comes. Given the diverse social, cultural, and environmental conditions, a variety that may be appropriate for one farmer is not necessarily appropriate for another. Hence, the best option is the seed she selects and knows.

Two other important factors are security and cash savings. During fieldwork all informants seemed to share the view that saving seed provides a sense of security. Once the seed is selected and safely set aside, one can rest assured knowing that the seed for the next planting season will be available when needed, avoiding costly and yield-reducing delays in planting. Having saved seed also means not having to spend money or time acquiring seed at the last moment before planting when prices typically rise and many small-scale farm households are struggling to raise money for land preparation, planting, and other operations.

Saving seed is also strongly associated with the social norm of being a "good farmer." A good farmer is one that takes good care of her seed, and is expected to make every effort not to lose her seed. As the female farmers in one focus group explained it: " [losing seed]… is like hurting one's pride in being a good farmer – it is like a humiliation." It is legitimate however, for a farmer to obtain seed from other farmers in a bad year, provided he has followed the norm of "taking good care" of the seed. In this case, the person is someone who has a justifiable need for the seed and the donor is also assured that he will "take good care" of it. The recipient "deserves" the seed and will appreciate the favor, being someone who normally tries to select and keep his seed from the previous harvest, and therefore does not habitually rely on others for seed. This norm may also serve to discourage free riders, who frequently request seed from others but are incapable of serving as seed providers when the need arises. However, because the definition of a "good farmer" is somewhat ambiguous, the set of farmers who exchange seed is not a clearly defined group or club, but rather a "fuzzy club."

Finally, farmers admit to feeling affection for their own seed. The seed may be an inheritance, passed from parents to children when the latter start farming independently. Usually, the seed is given to a young couple by the husband's parents. In some cases, however, they may receive the seed from both sets of parents or, in special cases, only from the wife's.[7] Often, the seed may have been in the family for many years, being seen as contributing significantly to its sustenance, and thus being revered or attributed with symbolic value beyond its immediate utility in the farming system. For many small-scale

[7] In the cases we know, this occurred either because the husband did not have relatives in the community, relatives had no seed to give, or there were bad relations between the couple and the husband's family. The case of Lucio and Felicitas is an example of the latter. Lucio's parents did not want to acknowledge the marriage between the two. They did not offer seed to the young couple, who on the other hand did not want to ask for it. Instead they received seed for their first maize crop from Felicitas' parents.

farmers in the Central Valleys, their maize seed lot is an heirloom linking them to forebears and which they, in turn, will pass on to future generations. Saving seed, therefore, becomes a way of conserving and honoring important traditions and family ties.

REASON FOR ACQUIRING SEED FROM OTHER SUPPLIERS

Only 24.2% and 20.9% of the farmers in the tracer study engaged in seed acquisitions or distributions respectively in 2001. Focus group discussions and in-depth interviews with key informants identified many reasons for seed exchanges. These were quantified during the tracer study and divided into four themes: (1) establishing a new farm household, (2) lack of sufficient seed for planting, (3) experimentation, and (4) initiatives by other farmers (Table 2).

Table 2--Reasons for acquiring maize seed

Theme	Total number of recorded seed acquisitions Reasons for acquiring seed (% of acquisitions)	317
Establishing a household	Establishing a household	27.8
Lack of sufficient seed	Complete seed loss	5.4
	Did not save seed from last year	4.7
	Partial seed loss	3.8
	Harvest loss	3.8
	Sold it all	0.6
	Seed loss due to pests in storage	0.6
	For replanting	0.3
	Subtotal	19.2
Experimentation	Liked the seed	26.5
	"To see if it works"	4.1
	Bought grain for consumption, but so nice they selected seed from that	1.6
	Subtotal	32.2
Others' Initiative	Someone else asked for a seed exchange	2.2
	Someone brought the seed as a present	3.2
	Subtotal	5.4
	Other	15.5

As stated previously, when people establish independent households they usually get seed from parents.

A lack of seed in a household may be due to partial loss from low yields or total loss from drought, water logging, insect attack, weeds, hail, or poor management. Seed may also be lost in storage to insects or rodents. Farmers may be forced to sell or consume their entire harvest in the case of an emergency (sickness, an accident, other problems). Farmers who produce maize for fodder may harvest before seed is produced.

Seed loss can be partial or complete. The former, which is the most common case, normally results in mixtures of seed being sown, through farmers complementing the seed they lack with relatively small amounts of additional seed. In the latter case, complete substitution of the former variety can occur. People, who for some reason, e.g. temporary migration, decide not to plant maize for some time, often face a similar situation due to the relatively fast decline in maize seed germination rate and vigor (Morris 1998).

It is interesting to note the relatively low number of acquisitions reported as addressing seed loss. There is a social stigma associated with seed loss, even though in most circumstances it may be beyond farmers' control. Still, in line with the "good farmer" notion described above, informants said that seed loss can be associated with laziness, lack of knowledge, and inappropriate practices. Never having lost one's seed is a source of pride for farmers, who would naturally be reluctant to talk about occasions when they may have lost their seed. It is possible, for example, that informants in the tracer study who said they had acquired seed simply because they really liked it may also have had a serious need for it, and otherwise might not have sought it in the first place.

Like farmers elsewhere, many small-scale farmers in the Central Valleys are curious and want to try new options. They may believe that other farmers' maize varieties seldom work for them, but are also on the lookout for worthwhile traits or advantages in varieties grown by peers. Furthermore, they also recognize that "foreign" seed can eventually become adapted to local conditions,[8] if planted and selected under those conditions. This leads to many instances in which farmers try out other materials or

[8] The term "creolization" or rustication—applied elsewhere in Mexico to denote a loss of improved traits in improved varieties—can actually name the process by which farmers adapt "foreign" varieties, improved or otherwise, to local conditions (Bellon and Risopoulos 2001).

combine or cross them with their own materials to see what happens. On occasion farmers actively seek maize with specific characteristics they would like to incorporate into their own maize. Others will look for seed more generally in the hope of obtaining a kind of maize that is particularly good for special uses or dishes. They may eventually decide to incorporate such acquisitions into their own permanent collections of maize populations. To minimize risk, farmers usually experiment with small amounts of seed or on small plots. It should be pointed out that this is the largest category. Furthermore, if one excludes the category of seed acquired to establish a new household, experimentation accounts for 44.5% of seed acquisitions, compared to only 26.7% for the category "lack of sufficient seed."

Farmers can get seed from other farmers without actively seeking it, in cases where another farmer requests a seed-for-seed exchange or where the seed is a gift. The receiving farmer may eventually decide to plant the seed. The sister of one of our informants brings small amounts of maize seed from her own maize field every year when she visits him. Our informant, who plants this seed, says 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.

According to the tracer study, the amounts of seed involved in farmer-to-farmer transactions are often quite small (Table 3). For many transactions, the exact quantity was unknown, but nearly half the rest involved only 8 kg—enough to sow 0.5 ha—or less. Plots in the Central Valleys are generally small and require relatively little seed, but the frequency of small seed transactions suggests experimentation or partial seed loss as the

most common reasons for acquiring seed. This bears out findings by the CIMMYT/INIFAP project conducted prior to the work described here (Aguirre et al. 2002). It is also consistent with the view that farmers' main source of seed is their own fields. Seed flows among farmers occur at the margins of this practice.

Table 3--Quantity of seed involved in transactions

Total number of transactions[a]	421
Quantity of maize seed per transaction (kg)	% of transactions
≤4	24.7
5-8	23.0
9-12	14.7
13-16	10.2
17-20	10.5
21-40	10.9
41-100	4.8
>101	1.2

[a]No data for 110 transactions

REASONS TO PROVIDE SEED TO OTHER FARMERS

The tracer study records two main reasons for farmers giving seed to others: (1) social responsibility or (2) to obtain something in return, e.g. money or seed (Table 4). In another paper (Badstue et al. 2003), we have argued that access to seed in the study area may be understood as stemming in part from a general sense of social responsibility. This is confirmed by the current results, showing that the reasons stated for most of the distributions registered have to do with helping the recipient. In particular, the idea that if

a fellow farmer asks for seed and one has sufficient seed, one cannot deny it. As stated by various informants: “I provided him the seed because I had it!”

Table 4--Reasons for distributing seed

	Total number of distributions	195
Theme	Reasons for distributing seed (% of distributions)	
Social obligations		57.4
	The farmer was asked for seed and had no reason to deny	3.1
	A seed interchange was asked for	1.0
	A barter was solicited	1.0
	For reasons of compassion	4.1
	Obligation	3.1
	For being kin	69.7
	Subtotal	
Obtain something in return		5.6
	Needed to obtain money	11.8
	Sell seed and/or grain	1.0
	To obtain seed	7.2
	Provide seed to sharecropper	25.6
	Subtotal	
	Others	4.6

Most farmers who provided seed received something, either cash or seed, in return. However, the fundamental motivation was their sense of social obligation, rather than to make a profit, and what they received was in fact simply fair compensation that allowed them to break even in the transaction. Having said this, in 17.4% of the

transactions, the seed providers sought and obtained a profit. Most of the seed-for-profit transactions were associated with two persons who are known to sell seed every year.

These findings suggest strong cultural values associated with being helpful to others. People who are not willing to provide seed to others are considered selfish. In interviews with key informants, an important motivation for many seed providers is that the person requesting the seed has a genuine need for it. Finally, a general sense of reciprocity, rather than a specific obligation to particular individuals, was mentioned, as in the words of one informant: “What goes around, comes around.”

DIFFERENT TYPES OF SEED TRANSACTIONS

Informants described different types of seed transactions in detail during ethnographic interviews and focus group discussions. Quantitative data on seed transactions were later gathered in the seed flow tracer study. Transactions were classified in seven categories, including “other” which referred to infrequent, ad hoc transactions (Table 5).

Table 5--Types and number of seed transactions

Type of transaction	Description	Transactions		Acquisition		Distribution	
		#	%	#	%	#	%
Purchase	Seed that has been bought and paid for in cash	280	52,7	143	42,7	137	69,9
Inheritance	When parents or foster parents pass on maize seed to their children or foster children. This can be when the parents die, or when the children become independent of their parents and start to farm on their own	89	16,8	84	25,1	5	2,5
Exchange	Seed of one kind of maize is exchanged for the same quantity of seed of another kind of maize. Sometimes seed is acquired in exchange for grain, but quantities normally vary, as seed has higher value than grain	52	9,8	37	11,0	15	7,7
Gift	In this transaction seed is provided without payment whether monetary or in kind	49	9,2	32	9,6	17	8,7
Barter	This is an exchange in kind, i.e. maize seed for some other good, which is of use to the seed provider (e.g., beans or coffee)	7	1,3	4	1,2	3	1,5
Borrowed	The seed provider hands over the seed to the person requesting it, with the latter in turn promising to give back the same quantity of seed of the same kind of maize once it has been harvested	3	0,6	-	-	3	1,5
Other	This category contains various other ways of obtaining seed: sharecropping[1], pepena[2], seed won in a lottery, payment realized in kind with maize, and seed acquired without the knowledge of the seed provider	51	9,6	35	10,4	16	8,2
Total		531	100%	335	100%	196	100%

[1] In this arrangement the owner of the land contributes the plot of land and the seed while the other contributes the labor. When the harvest is over, they split the harvest (in most cases equally) between the two of them.

[2] The practice of collecting one by one grains that are left over on the ground in the field after the harvest.

The quantitative data clearly show the heterogeneity of transactions, although purchases account for half. Focus group discussions and informant interviews provided detail on the many types of transactions and their individual variations. We had expected a relatively uniform and clearly defined mode of transaction, reflecting adherence to a set of rights and responsibilities and a system of collective action. This was not what was found. Furthermore, while most informants remembered from whom they had obtained seed in the recent past, many had difficulty recalling to whom they had given seed. This can explain the noticeable discrepancy between the number of acquisitions and distributions.

Most seed transactions carry no obligation beyond the immediate transaction, except for borrowed seed or that given as a gift. The borrower must repay the seed, sometimes but not always including interest, and gifts usually carry an implicit obligation to return the favor.

SOCIAL RELATIONS

The in-depth interviews and focus group discussions brought to light categories of social relations frequently involved in seed transactions (Table 6). These were later quantified in the tracer study. The "seed provider" categories mentioned here do not constitute an exhaustive list. Each category could also be sub-divided, and subcategories will overlap and show variations among them. For example, neighbors can sometimes also be relatives or *compadres*.[9] This grouping reflects the informants' own

[9] From the word c*ompadrazgo,* 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. Often there is a certain degree of prestige associated with being asked to become someone's compadre or comadre, and in some ways compadrazgo can signify social capital (Cordero Avendaño de Durand, 1997).

classifications; that is, an informant referred to a seed provider as an "uncle," the provider was classified as family member, though the person might also be a neighbor.

Table 6--Transactions per type of seed providers

Social relation of seed provider	Description	Transactions		Acquisition		Distribution	
		#	%	#	%	#	%
Family members	This group includes blood relatives as well as affiliated relatives	247	46,5	177	52,8	70	35,7
Compadres	Very close relations, considered almost like family. When asked for help they cannot easily refuse (Beals 1970)	25	4,7	13	3,9	12	6,1
Neighbors	Neighbors. It should be noted that neighbors often also are relatives or compadres	7	1,3	5	1,5	2	1,0
Friends	Include workmates and people who belong to the same social organizations, church group, or communal work group. Their role is significant both as a source of information and in terms of exchange or mutual help	38	7,2	22	6,6	16	8.2
Acquaintances	This group includes sharecropper relations and owners of neighboring fields, plus other persons people know, but with whom they do not have close social ties	157	29,6	70	20,9	87	44,4
Strangers	Persons of whom nothing or very little is known. With strangers seed is usually sold for cash, as no relation of trust or familiarity exists	19	3,6	18	5,4	1	0,5
Others	Includes commercial seed vendors, shopkeepers, government or NGO programs etc	38	7,2	30	8,9	8	4,1
Total		531	100%	335	100%	196	100%

People obtain seed through many types of social relationships. Family members and acquaintances are the most common. Most seed transactions took place between people who already knew each other and who shared a feeling of mutual obligation. Informants in focus group discussions and ethnographic interviews were not able to identify specific persons as particular seed-relations (except for researchers involved in the CIMMYT/INIFAP project that included a seed distribution activity). The data regarding social relations does not provide evidence of farmers' involvement in specialized institutions for the mutual supply of seed.

RELATIONSHIPS AMONG SOCIAL RELATIONS AND SEED TRANSACTIONS

Trust in general is important for these farmers. Trust in the seed may often derive from a relationship of trust between the recipient and the provider. There is a slight association between transaction type and supplier-recipient relationship (Table 7). Inheritance or, less frequently, gifts are the most common transactions among kin, whereas purchases predominate among acquaintances and strangers. Gifts are nonexistent among acquaintances and strangers. Purchases, on the other hand, constituted a frequent type of transaction in all cases. Informants also said that, in barter and exchange among acquaintances and strangers, quantities were calculated based on market prices, but rates in transactions with kin or a close relationship might be more favorable. Clearly no particular type of transaction is restricted to a single category of seed supplier. Closeness of social relationship improves chances of preferential treatment, but does not determine type of transaction—consistent with Sahlins' (1972) findings on primitive exchange. Most transactions involve a feeling of trust between provider and recipient, either through consanguineous or affiliative kinship, *compadrazgo*, or friendship.

Table7--Types of transactions by groups of seed providers.

Seed provider's social relation to seed receiver	Purchase	Exchange	Other (Barter, borrowed, share-holding etc.)	Gift/ inheritance	Total no. of transactions
Kin[1]	90 (33 %)	27 (10 %)	25 (9 %)	130 (48 %)	272 (100%)
Friends / Neighbors	34 (61 %)	12 (21 %)	7 (13 %)	3 (5 %)	56 (100%)
People the seed receiver knows	126 (75 %)	10 (6 %)	26 (16 %)	5 (3 %)	167 (100%)
Strangers	30 (86 %)	3 (9 %)	3 (6 %)	0 (-)	36 (100%)
Total	280	52	61	138	531 (100%)

[1.] Here both consanguineous and affiliative kinship as well as *compadrazgo*.

Both in interviews and focus group discussions, informants emphasized that seed must be both of good quality and appropriate for target production conditions and preferences. Some seed seekers also take into consideration the way the seed has been cultivated and what they know about the general quality of a supplier's work. These complex requirements make it difficult for those seeking seed to obtain appropriate information. The problem is exacerbated by the lack of an accepted and clearly defined nomenclature for local maize varieties, beyond broad categories such as grain color and width and growing cycle, as described in previous research in the area (Smale et al. 1999) and confirmed by both Zapotec and Spanish speaking farmers in the present study.

The easiest source of knowledge and trustworthy information, not surprisingly, is the people with whom the farmer already has close social relations. Farmers may already know the characteristics of varieties used by kin or close friends, and can easily obtain more information. Conversations with family members, compadres, and neighbors, as well as paying attention to what other farmers were growing, were among the most frequently reported ways of obtaining information about seed used elsewhere in the

community. Acquiring seed from trusted sources reduces the risk of obtaining inappropriate seed. Similarly, seed transactions can occur through many types of social relationship, so farmers are not dependent on a single supplier.

FREQUENCIES OF SEED TRANSACTIONS

It is difficult to assess the frequency of seed transactions; farmers do not keep records of such transactions, so estimates must rely on the memories of those interviewed. In the tracer study, seed transactions involving current cultivars were carefully registered, noting the year they took place and allowing farmers to go as far back in time as desired. Recent transactions are more likely to be remembered than those from a long time ago. Notwithstanding these limitations, an estimate of the frequency of seed transactions was calculated. Table 8 shows the average number of transactions per farmer for the three most recent years. The distribution between acquisitions and instances of providing seed is approximately the same, meaning that on average acquisitions occur 0.31 times every year and provisions occur and 0.39 times a year—in both cases, approximately once every three years. Furthermore, only 24.2% (acquisition) and 20.9% (provision) of the farmers engaged in seed transactions in 2001, according to tracer study data. Seed transactions are apparently infrequent and do not involve a large number of farmers every year.

Table 8--Frequencies of acquisitions and distributions per year per farmer across most recent years.

Year	Average number of acquisitions/farmer/ year	Average number of acquisitions/farmer/ year
2001	0.31	0.39
2000	0.25	0.30
1999	0.23	0.24

GENETIC IMPLICATIONS OF THE SEED SYSTEM

Farmers in the study area maintain diverse maize landraces and thereby contribute to the conservation of maize genetic diversity (Bellon et al. 2003; Smale et al. 2003). Research using neutral markers[10] has shown no genetic structure for landrace populations collected in the study villages, but analysis based on phenotypic traits shows strong structure associated with farmers and communities (Pressoir and Berthaud 2003). By definition neutral markers are not under selection; they provide information on the evolutionary history of a population (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. On the other hand, phenotypic traits of varieties collected from the same farmer or same community are more similar in their characteristics—mainly ear and grain traits—than those 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. Furthermore, experiments with these landraces have shown that they contain high rates of deleterious mutations. Such mutations are expressed in homozygous plants. Gene flow promotes heterozygous plants, hence mitigating the

[10] Variation in DNA that can be detected and that is not necessarily translated into a selective advantage.

expression of the deleterious mutations, a phenomenon that has been called “genetic rescue” (Keller and Waller 2002). Gene flow therefore seems to be playing an important role in preserving the viability of these landraces for farmers.

Definitions of "type" or "variety" based on molecular analyses of the diversity of maize samples from two farmers over time—including both a creolized variety derived from a hybrid and a landrace—differed from the farmers' own definitions (Ramirez, in preparation) The farmers said the landrace and the creolized variety were the same, but genetic analyses showed them to be quite different and that the level of genetic diversity changed over time. For example, molecular analyses comparisons of seed of the creolized variety with that of the original hybrid showed them to be completely different. This suggests that the farmers did not report or pay attention to changes in the variety over time, and illustrates the difficulties of linking what farmers tell us about the maize populations they grow with their actual genetic identity. It also demonstrates the dynamic nature of seed exchanges in the study area, a level of seed flow that farmers may underestimate.

These results corroborate our other observations on farmers' seed exchange practices. First, the practice of selecting and saving one's own seed is the basis of the phenotypic diversity and the seed exchange "system" in the study area. One could say that each farmer creates and maintains her own, almost unique maize varieties. Second, gene flow is an important way in which farmers add new traits, modify varieties to fit their needs, and keep their varieties "healthy"—that is, maintain viability in the face of deleterious mutations. Gene flow most commonly occurs when farmers experiment with “foreign” seed, mixing new varieties with their own to creolize them. Current seed

practices allow farmers to experiment and incorporate new varieties into their collections, while conserving varietal traits suited to their needs and environments. The system is very dynamic, which complicates its analysis, particularly since farmers may underestimate the changes that take place in their varieties.

5. DISCUSSION

The hypothesized existence of specialized collective action for maintaining access to seed of diverse maize landraces, in terms of a well-defined group of farmers linked by a set of rights and responsibilities in relation to the mutual supply of seed, led to a series of predictions. The results showed that the predictions were not fulfilled. First, although seed transactions occur within a set of social relations, one would have expected informants to be able to name particular people whom they rely upon to get seed recurrently, which they did not. In many cases, they had trouble remembering the people with whom they had had transactions. Second, there were many different types of seed transactions. Transaction type can vary even under similar circumstances, and transactions are bilateral, whereas a specialized and organized collective action scenario would involve a set of well defined practices and a distinct group of farmers. Third, most transactions do not involve any long-term obligation between supplier and recipient. The seed supplier-recipient relationship usually ends with the completion of the transaction.

There are, however, general cultural norms regulating the circumstances under which it is appropriate to ask for seed, whom to ask, and to whom one should provide seed. In particular, those who are considered “good farmers”, because they take care of their seed, are often asked for seed and may ask for seed from others, particularly if they

have lost theirs through no fault of their own. However, the definition of a "good farmer" is somewhat ambiguous. Thus, the set of farmers who exchange seed is not a clearly defined group or club, but rather a "fuzzy club."

Part of the rationale for the original hypothesis relied on an assumption that seed loss was the principal driving force behind seed transactions. The results showed that this is not the case and that a more important driver is farmers' experimentation. Clearly experimentation is a form of managing risk to acquire information, but it is related with curiosity and the search for new maize types that fit farmers' needs. More importantly, the data show that seed transactions are infrequent, so the fixed cost of a specialized organization to access seed may be larger than the cost savings for individual transactions, meaning that it would not be worthwhile.

When farmers occasionally do obtain seed from other farmers, it is mainly from close social relations. There are good reasons for this. The cost of obtaining information on different varieties and availability of seed should be relatively low, given that seed can be obtained as part of normal, frequent social interaction. The social ties give rise to trust and confidence that the seed has the desired characteristics and quality. At the same time, farmers often have first-hand knowledge of the varieties grown by their relatives or friends. If the variety is grown in the same community under conditions similar to those in the farmer's own fields, uncertainty related to environmental adaptation is reduced. Finally, obtaining seed from a close social relation can often secure preferential treatment in the transaction. Even though obtaining seed from close social relations has many advantages, farmers still do get seed from people outside their family circle, particularly through purchase. Close social relations are an important but not exclusive source of seed

for farmers. This emphasizes the flexible and sometimes ad hoc nature of seed transactions among farmers.

Farmers generally save seed from one crop cycle to the next. The need to acquire new seed is therefore occasional, rather than constant or recurrent. The incentives for specialized and organized collective action may be low, because the fixed costs may exceed benefits, given the relatively low frequency of acquiring seed off-farm. Access to seed from other farmers is instead part of a more general social responsibility for mutual assistance. Social networks and factors such as loyalty, mutual help, reciprocity, confidence and feelings of social obligation that can be interpreted as aspects of social capital, are central to seed flows among farmers. For example, "friends"—meaning people who belong to the same social organizations, church groups and communal work group—is the third most frequent type of participants in seed transactions after family and *compadres,* and their relative order relates directly to their social capital component. Although there is no formal organization to handle seed transactions, seed flows between friends show that social capital and collective action for purposes others than seed exchanges are used to gain information on seed and undertake actual transactions. Other studies have shown that collective action for unrelated activities influences the ability to cooperate in a different activity (e.g. McCarthy et al. 2004). In our case, social capital (in family and *compadres* categories) and collective action (friend category) in other spheres provide "cheap" information and reciprocity for seed exchanges. So social networks as well as collective action in other spheres (friend category) are exploited for seed exchanges. In particular the infrequency of seed transactions helps explain the absence of

specialized collection action for seed exchanges and the reliance instead on existing social networks and collective action in other spheres.

The definition of "specialized and organized collective action" used here is quite restrictive: it is confined to formal organizations with very strict group membership with the sole purpose of supporting seed flows. Consider however more informal institutions with rules that are not predetermined and that adjust to contingencies. These rules are 'fuzzy' and more difficult to identify, but are also more flexible and better suited to deal with risk and uncertainty (for example, crop failure, storage problems) and relatively rare exchanges. Add to this the desire to experiment. Under these circumstances, it would be reasonable to conclude that some degree of collective action has at least a secondary role in seed exchange systems. Even the fact that farmers rely on different sources of seed might not indicate a complete absence of collective action, but might be a way to reduce the risk of crop failure and maintain the freedom to experiment and respond to changing and relatively infrequent seed needs.

Our research showed that the core principle of the seed "system" in the study communities is farmers' practice of selecting and saving their own seed. Seed flows occur when this fails or when farmers want to try other varieties. Seed flows in the study communities take place at the periphery of the system. The results presented here suggest the following organizing principles for seed exchanges.

1. The concept of the "good farmer."
2. The lack of transparency in the seed: one cannot know the traits and the performance of the plants that will grow from it, while at the same time these are what a farmer cares about (Morris 1998). This lack of information is exacerbated by the lack of a commonly recognized and

clearly defined local nomenclature for local maize varieties that goes beyond broad categories (e.g., grain color, width, growing cycle).

3. A demand for diversity by farmers: farmers value multiple crop traits and different farmers require distinct varieties based on their needs, preferences, and constraints.
4. A clear understanding of genotype-by-environment interaction: one size does not fit all—the main reason that farmers maintain diverse maize varieties (Bellon 1996).
5. An interest in experimentation.
6. A belief in the ability to modify foreign seed to suit local needs.

Given 1-3, it makes perfect sense to keep one own seed. The seed is well known and it has the desired characteristics and performance (production, consumption requirements). These factors argue for very conservative behavior in farmers, when it comes to accessing seed. At the same time, farmers recognize that other maize varieties may be useful or desirable and thus like to experiment with seed from other farmers and believe in creolization—the ability to tailor foreign genotypes to local needs and preferences, if the seed is grown in the appropriate environment and selected properly. Foreign seeds can also be mixed with one's own to create new, desirable combinations. This practice has been described for other farmers in Mexico (Aguirre 1999; Perales et al. 2003). These factors motivate innovation and foster an interest in obtaining foreign seed, thereby counterbalancing the conservative behavior described above. These principles translate into a resilient system that is partly conservative but that can innovate as well. They are also consistent with the fact that seed exchanges are usually infrequent, involve small quantities of seed, and require trustworthy information, normally (but not always) from sources with whom one has close ties—family members, *compadres*, and neighbors.

Seed exchanges are not primarily commercial, but are part of a moral system based on trust and social responsibility.

Our investigation based on the "specialized and organized collective action" hypothesis for seed exchanges helped us to discover the more informal and ‘fuzzy’ characteristics of the existing seed exchange system.

6. DISSEMINATION OF RESULTS

Two meetings were carried out with local scientists, policy makers, community authorities and farmers to “give back” the results from the project. The meetings provided an opportunity to discuss these results and reflect on their implications. Many of the participants—particularly those involved in policy interventions—were somewhat surprised with the complexity of the system and, particularly, with the fact that farmers were not bound by some static notion of tradition. They are conservative and innovative at the same time and for good reason. For participants involved in government programs that distribute improved seed, it was an eye-opener. Their efforts had not been very successful, because farmers do not adopt the new varieties after testing them, possibly because they did not trust the "seed." Part of the problem could be the narrow view of the term "improved variety” in such programs. Often the primary emphasis is on grain yield, whereas farmers value diverse traits.

There was a discussion about establishing community seed banks, and the idea was rejected by the participants. It may be more important to give farmers access to the maize diversity present by creating some sort of “virtual” collection with relevant information about who is growing what. It is not clear though how this can be done.

There was also another discussion about a group of women who have created a network to sell hand-made tortillas in the city of Oaxaca. They are creating a demand for landrace maize and an incipient marketing system is developing around them. Clearly, consumers have to be involved in the system to improve its viability.

7. POLICY IMPLICATIONS

To maintain genetic diversity on-farm in this area, the integrity of the seed system has to be maintained. This means that farmers should be able to continue to save and select seed, but also to have access to other varieties that may be of interest to them. Hence seed flows among farmers should be sustained.

The present system seems resilient. Relatively few farmers need or request seed and this means that it is relatively easy to find somebody to provide it. However, this also depends on having large numbers of farmers. If the farmer population declines substantially, the seed available for exchanges among farmers may diminish enough to jeopardize the maize diversity maintained in this system.

Supporting farmers' efforts to maintain genetic diversity on-farm may require external interventions that reinforce the current processes. Fostering an information-rich environment seems essential—farmers should know who is planting what and have access to relevant and trustworthy information about the varieties grown. Interventions that promote low-cost, low-risk access to new and interesting varieties for experimentation, as was done during the CIMMYT/INFAP project, could be valuable. Such interventions should build trust, which suggests that they should invest heavily in building and/or developing social capital among farmers and between farmers and the

outsiders promoting the interventions. One should be careful however of interventions that try to create specialized organizations with the sole purpose of dealing with seed issues and that rely exclusively on farmers' willingness to act together to maintain diversity; e.g., community seed banks. Based on our results, it seems unlikely that such set-ups would work.

Given the way the current seed system is organized, it is unlikely that a market for seed will develop. Since most farmers save seed, the demand for outside seed is small. In this system one size does not fit all or at least a "few sizes do not fit all." Nobody can make a business out of selling small amounts of many different things. Donors have subsidized interventions such as those practiced in the CIMMYT/INIFAP project. The fact that, as part of this project, farmers purchased seed of diverse maize varieties proves that there is a demand for seed of farmers' varieties, but only in small quantities and for experimentation. Supplying such seed may not be a self-sustaining enterprise.

The system could evolve towards more and larger quantities of seed moving among farmers, if the number of farmers declines and the area planted per farmer increases. This could represent a movement toward a more commercial system with less diversity. The nature of the seed system would then be changed dramatically, and probably diversity as we observe today will also change as well. To the extent that these changes result in improvements to these farmers, then they should be welcomed. The danger, however, is that this may not happen and that, in the bargain, maize diversity may be lost.

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