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The dynamics of seed flow among small-scale maize farmers in the Central Valleys of Oaxaca, Mexico[1].

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Abstract

This paper describes and analyzes the way in which small-scale maize farmers in the Central Valleys of Oaxaca secure access to seed of a diverse set of maize landraces. Six communities were studied, three of them more in depth. Several methodologies were used including in-depth semi-structured interviews with key informants, focus group discussions, ethnographic case studies, and a tracer study--following the flows of seed among different farm households. A range of different types of seed transactions and social relations involved in smallholder seed supply were identified and described. Seed flows are mediated by social rules and relationships. While the most common transaction is the sale of seed, this is not done for profit but out of a sense of moral obligation. We identified several organizing principles of these seed systems: the concept of a "good farmer", the lack of transparency in the seed, demand for diversity by farmers, a strong belief in genotype by environment interaction among farmers, an interesting experimentation and a belief in their ability to modify "foreign" seeds to suit their needs. These principles translate into a resilient system, that is partly conservative, but that can innovate as well. The implications of these findings for on farm conservation are explored.

Key words: maize, informal seed systems, Mexico, genetic diversity, seed flows

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1. Introduction

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 that produce for self-consumption in the latter usually depend mostly on themselves to access seed. These "informal" seed systems are still the prevailing source of seed in developing countries and many studies have stressed their importance, though little is known about how these systems function (Cromwell, 1990; Almekinders et al., 1994; Wierema et al., 1994; Thiele, 1999). In Mexico, it is estimated that 80% of the area planted to maize is done so with recycled seed, i.e. seed selected from the previous harvest by farmers (Morris and López Pereira 1999), and hence involve informal seed systems. Therefore, these seed systems are of great importance for the well-being of small-scale maize farmers in Mexico, as well as for the viability of their agriculture.

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 in press; Hernandez 1985; Perales et al. 2003). The structure and evolution of genetic diversity in maize germplasm depend on farmers' access to a diverse array of farmers varieties[2] and therefore on the

[2] *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. Even if considered similar, one farmer's variety can be somewhat distinct or distinguishable from the variety of another farmer (see Pressoir and Berthaud, 2003)

flow of varieties and seeds among households and communities, i.e. the informal seed systems (Bellon et al. 1997; Louette et al. 1997). In order to be able to address the growing concern for the loss of crop genetic diversity and the importance of conservation of genetic resources in situ, it is necessary to know more about these seed systems. The dynamics of these systems have important implication not only for the conservation of genetic resources on farm, but also for designing and implementing interventions to support on farm conservation (Bellon in press).

Originally the project on which this research is based addressed the hypothesis that individual farmers would have strong incentives to participate in some form of collective action with other farmers in order to ensure access to a larger base of maize genetic diversity than they would be able to manage individually. As the research progressed it became clear that that there was no evidence of collective action, which other results later confirmed this (see Badstue et al. 2003). This led to a reorientation of the research towards a general description of how farmers access seed of diverse maize varieties and understanding the reasons behind their decision to acquire seed, and hence to a general study of the local informal seed supply system. The fact that no evidence of collective action was found does not mean that there are no local institutions that mediate the seed supply, simply that these are based on other principles and incentives.

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. This paper addresses the following questions: how do farmers access seed? Why do they save seed? Why do they acquire seed? Why do they give seed? What are the factors that influence the organization of the local seed system? And what are the implications of these results for interventions to support on farm conservation?

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 (Aguirre 2002; Bellon et al. 2003; Smale et al. 1999). 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 seed systems on which these farmers depend.

2. Methodology

In this research both qualitative and quantitative methods were used, including in-depth, semi-structured ethnographic interviews on a variety of issues related to maize and maize seed supply; focus group discussions; and a tracer study of seed flows between farm households. The different methods complemented each other and ensured that key issues of the investigation were addressed from several angles.

The study was carried out in six communities in the Central Valleys of Oaxaca: San Pablo Huitzo, Santo Tomás Mazaltpec, San Lorenzo Albarradas, San Agustín Amatengo

and Santa Ana Zegache. They were the same where the CIMMYT/INFAP project took place. This meant that a body of background information about these communities was already available. Originally these communities were selected for their contrasting characteristics in terms of maize yield potential and dependency on non-farm income (Smale et al., 1999). In each community, the informants selected represented different social groups in terms of gender, age, ethnicity, economic level, and level of formal education.

At an early stage in the research process an initial assessment of local practices for accessing seed of diverse maize materials was conducted through in-depth ethnographic interviews with 22 key informants from three of the six studied communities: Santa Ana Zegache, San Lorenzo Albarradas and San Pablo Huitzo. They were chosen because they represented the most contrasting conditions of the six. No evidence of institutions of collective action with particular respect to seed was identified in this early survey. This led to a redirection of the research focus and a adjustment of methodology towards a more general description of how farmers access seed of diverse maize varieties and understanding the reasons behind the apparent lack of collective action in this particular respect.

A series of 12 focus group discussions was carried out (one for men and for women in each of the 6 communities). The focus group discussions dealt with the relative importance of seed loss among different vulnerability factors faced by farmers, and the mechanisms that guide different seed transactions. The discussions were furthermore

accompanied by the acting out of seed exchanges by participants. In total 46 women and 58 men participated in this activity.

The survey-based seed flow tracer study involved male and female representatives from 153 individual farm units in the same three communities as the initial assessment mentioned above. Special attention was given to events of seed acquisition and seed distribution and a total of 531 seed transactions were registered. Incoming and outgoing maize seed flows of diverse households were carefully noted and mapped out with special notice to the type of transaction and the social relations involved. Ten households in each community were selected as the starting point for the tracer study. They were chosen using similar criteria as described above for the selection of informants. A first round of interviews was carried out; with the information gathered during these interviews—information on other households that gave or received seeds—a second group of households was located and interviewed.

3. The Study Area

The study area referred to here is comprised of six communities in the Central Valleys of Oaxaca. Yearly medium temperature in this region is 18-22 °C with an average annual precipitation between 600 – 1000 mm (INEGI, 2001a). The rainy season runs from May-October. Maize, beans, and squash are the most common crops and average farm size in the study area is 3.49 ha (Smale et al., 1999). The farming systems in all of the 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 furthermore have secondary schools, and Santa Ana Zegache and San Lorenzo Albarradas each have a tele-secundaria (a national secondary school program via television).

The population in the study area is predominantly Spanish-speaking, but both in Santa Ana Zegache and in Santo Tomás Mazaltepec a large part of the population (>30%) belongs to the Zapotec ethnic group and speaks Zapotec as their first language, although in both communities almost all Zapotec speakers also speak Spanish and only very few people do not speak Spanish, 1.3% and 0.9% respectively (INEGI, 2001b). Table 1 presents a series of characteristics of the six studied communities.

Table 1

4. Results

Maize agriculture in the Central Valleys of Oaxaca continues to play a significant role in farmers' livelihoods as a source of food security, appreciated local maize products such as *tamales* and *tlayudas*, and income. Farmers in this region value their landraces and

continue to plant them, and by doing so they contribute to the conservation of maize biodiversity (Bellon et al. 2003; Smale et al. in press). 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 or rely on other farmers to acquire seed. 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). Furthermore, only 24.2% and 20.9% of the farmers in the tracer study engaged in seed acquisitions and distributions respectively in 2001.

4.1 Reasons for saving seed from one's own harvest

The basis of farmers' seed supply is the individual practice of selecting maize seed from one's previous harvest and carefully saving it for the next planting season. All farmers in the study area do this. There are many reasons for this practice. First and foremost is "trust on his/her own seed." Farmers value multiple crop traits and require varieties with different combinations of them depending on their needs and constraints. For example, while most produce for self-consumption, some sell grain, others sell maize products, and some others use maize to feed animals; they farm under different conditions, some in flat fertile areas, while others in steep hills with shallow infertile soils. Furthermore, they strongly believe that a maize variety that performs well under certain conditions most likely would not under different ones, what breeders call a high genotype-by-environment interaction. All these circumstances are reflected in their seed selection: Farmers select maize seed according to a set of criteria or characteristics that they perceive as favorable in terms of their own particular needs, and they also know the performance of the plants

from which the seed came from. For social, cultural and environmental conditions, a variety that may be appropriate for one farmer is not necessarily appropriate for another, hence what better option to fit in one's own needs and preferences than the seed that one selects and knows.

Two other important reasons are security and the chance to save money. During fieldwork all informants seemed to share the view that saving seed provides a sense of security, as well as a chance to save money. Once the seed is selected and safely set aside, one can rest assured knowing that the seed for the next planting season is secured. Particularly that the seed will be available when is needed and the farmer will not incur in planting delays. This also means that when the time comes, one can avoid spending money and / or time acquiring seed at the last moment before planting, which is when prices typically go up and many small-scale farm households are struggling to raise the means necessary for land preparations, planting etc.

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 his/her seed. He or she is expected to make every effort not to lose his or her seed. As the female farmers in one of the focus groups stated when explaining that a good maize farmer should not loose the seed: " [losing seed]… is like hurting one's pride of being a good farmer – it is like a humiliation." It is acceptable and legitimate however, for a farmer to obtain seed from other farmers in a bad year, provided he or she 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 or she will "take good care" of it; this person "deserves" the seed and will appreciate the favor. The recipient farmer is not someone who does not make the effort to select and keep seed from the previous harvest (having to rely on others for seed). This norm may also reduce the problem of free riders; i.e., farmers who are always asking for seed but who are incapable of providing it to others.

Finally there may be an affection value associated with one's 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 man's parents. In some cases however, they may receive the seed from both the man and woman parents, and in some special situations only from the woman's[3]. Often, the seed has been in the family for many years during which it has been the sustenance of the family members, and whereby it has acquired an inherent affection or symbolic value. Thus, for many of the small-scale farmers in the Central Valleys, the maize seed lot is something they have in-trust, which links them with the ancestors, and which they, in turn, must pass on to their followers. Saving seed, therefore, becomes a way of conserving and honouring important personal ties.

Clearly the reasons to save seed are multiple and complex. They cannot be seen just as a simple narrow decision to save money, but as a decision that has different cultural, economic and agroecological components.

[3] In the cases we know of, where this occurred it was either because he did not have any relatives in the community; because they did not have seed to give or because of bad relations between the couple and the man's family. The case of Lucio and Felicitas is an example of the latter. Lucio's parents did not want to

4.2 Reason for acquiring seed from outside one's own harvest

While saving seed from one's own harvest is the basis of the local seed supply in the study area, farmers do acquire seed from other source from time to time. During the focus group discussions and in-depth interviews with key informants a multitude of reasons were identified and described and later quantified during the tracer study. The reasons can be divided into four themes: (a) commence farming, (b) lack of sufficient seed for planting, (c) experimentation and (d) initiative by other farmers.

Table 2 presents the reasons given by informants to acquire seed from others and their percentage relative to the total number of seed acquisitions recorded in the seed flow tracer study. The reasons are grouped by the four themes identified above. As indicated, when households become independent and start farming they usually get seed from parents, and not surprising this is an important reason to get seed.

Table 2

The lack of sufficient seed may be due to seed loss or of not being able or willing to save seed. Seed loss may occur because of low yield or total loss, due to drought, water logging, insect attack, weeds, hail, or poor management. Seed may be loss during storage due to insects or rodents. A farmer may not save seed, or at least not enough, because he or she may have to sell or eat everything that was harvested including the seed set aside due to insufficient production, an emergency or a crisis, e.g. a health problem, an

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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.

accident, etc. Farmers who produce maize for animal feed may harvest before seed is produced.

Seed loss can be partial or complete. Partial seed loss is when only part of the seed needed for the next planting is lost, and therefore only a portion of what is needed has to be acquired outside the household. Complete seed loss is when all the seed of a particular type of maize is lost. If the farmer wants to replace this maize type, new seed must be obtained. 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 associated with seed loss. There is a social stigma associated with seed loss, even though in most circumstances it may be beyond farmers' control. This stigma is associated with the notion of "good farmer" mentioned above. Informants pointed out that to a certain degree, seed loss is associated with laziness, lack of knowledge and appropriate working practices etc. Furthermore, never to have lost one's seed is a cause for pride for many farmers. Obviously, this does not motivate people to talk about the occasions on which they may have lost their seed. It is possible that this influenced the answers to the seed flow tracer study. For example, on some of the occasions, where informants said to have acquired seed because they really liked the seed they were offered, it is quite possible that this was not the only reason. In other words, even though they really liked the seed it is

possible that some of them would not have acquired the seed, if they had not had a serious need for it.

Like farmers elsewhere, many small-scale farmers in the Central Valleys are curious and want to try new options; while they may think 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, they also recognize that a "foreign" seed can eventually become adapted to local conditions[4] if planted and selected under those conditions. This leads 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". Some farmers may actively look for seed of maize with specific characteristics, which 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 certain special uses or dishes, which they may decide eventually to incorporate in their individual repertoire of maize populations. When farmers experiment with germplasm, it usually involves only small quantities of seed or land, in order to minimize the risks related to experimentation.

Farmers get seed from other farmers even if they do not ask for it, when another farmer asks and the farmer agrees to make a seed-for-seed exchange. Even if a farmer may not have actively looked for the seed, he or she may eventually decide to plant it, although this does not always happen. Another reason is when a farmer receives seed as a gift. For

example, the case of one of our informants, whose sister lives in another town, and who brings small amounts of maize seed from her own maize field every year when she visits her brother. 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.

The amounts of seed involved in farmer-to-farmer seed transactions according to the tracer study are often quite small (Table 3). In a relatively large number of transactions it was not possible to know the quantity involved. In the rest, almost half of the transactions involved 8 kg or less—16 kg are required to plant 1 ha of maize in this area. In spite of the fact, that plots are generally very small in the Central Valleys and therefore seldom require large amounts of seed, the high frequency 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 in order to complete the required amount of seed in the event of partial seed loss. This also was found by the CIMMYT/INIFAP project that preceded this research (Aguirre et al. 2002). These results are consistent with the view that selecting and saving one's own seed is the fundamental principle behind the organization of seed supply in these communities. Seed flows among farmers therefore occur at the margins of the system.

Table 3

[4] A process described in other parts of Mexico for improved varieties, but that applies to "foreign" varieties, regardless of whether they are improved or not and known as "creolization" or rustication (Bellon

4.3 Reasons to provide seed to other farmers

The flip side of acquiring seed is distributing it. Table 4 presents the reasons given by informants to give seed to others and their percentage relative to the total number of seed acquisitions recorded in the seed flow tracer study. The reasons farmers gave to provide seed to other farmers can be divided into two themes: (a) to help the recipient and (b) to obtain something in return, this basically could be money or seed. In another paper (Badstue et al. 2003), we have argued that access to seed in the study area may be conceptualized as part of a general social responsibility for mutual assistance. This is confirmed by the fact that the reasons most transactions associated with the distribution of seed 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!" This, however requires that the farmer who asks is considered a "good farmer," one who needs the seed and will take good care of it.

Table 4

The other theme involves obtaining something in return for the seed, mostly cash but also seed. It is important to note that in the first case, most transactions were associated with only two persons who are known to sell seed every year to a number of people. As described in the next section, most acquisitions were purchases, but relatively few distributions were done exclusively to obtain money in return, which suggests that the motive for selling rarely is to generate a profit.

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and Risopoulos 2001)

These findings suggest that in the study area there is a strong cultural value associated with being helpful to others, as long as one is able to do so (cover one own needs). For example, people, who are not willing to provide seed to others, are thought of as selfish. This ties up 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 is also part of a sense of reciprocity, as one of the informants pointed out: "What goes around, comes around".

4.4 Seed transactions and social relations

The transactions that mediate seed flows between farmers, as well as the social relations associated with them have been thoroughly described in another paper (Badstue et al. 2003). Here we just present a summary of these findings.

Farmers in the study area engaged in different types of transactions to acquire and distribute seed. Six types were identified: purchase, inheritance, exchange, gift, barter, and loans. The most common, purchase, accounted for more than half of all transactions, particularly for seed distributions. The types of social relations from whom people obtain seed are multiple. Family members and acquaintances are the most common. In general, the large majority of seed transactions take place between people who knew each other prior to the seed transaction and who share a feeling of social obligation towards each other (i.e. *compadres*[5]). Only a minority of transactions occurred between people with no

[5] 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

prior social relationship, i.e. strangers and other. A slight relationship between the type of seed transaction and the social relationship between seed donor and recipient was found. For example, gifts or inheritance are the most common transactions among kin, while purchases predominate among acquaintances and strangers. Furthermore gifts are infrequent with the former and non existent with the latter, although even among kin, purchase is a very frequent transaction. Additionally informants also said that while in barter and exchange the quantities involved in the transaction are calculated based on market prices, if the transaction happens between kin or a close relationship, the rates may be more favorable. In general, no particular type of transaction is restricted to one category of seed providers only. Nevertheless, it appears that close social relations improve chances of preferential treatment, but this is not a determining factor in determining the type of transaction that takes place.

5. Organizing principles of the seed system

The custom of selecting and saving seed from one year to another constitutes the basic or core principle behind the organization of seed supply in the study communities. Seed flows occur when for some reason saving seed did not work out, was not possible or when farmers want to try other varieties. Seed flows in the study communities hence, take place in the periphery of the seed system. The results presented here suggest that there are certain factors or organizing principles of the seed system in the study area. These include: (1) the concept of a "good farmer", (2) the lack of transparency in the seed, (3) a demand for diversity by farmers, (4) a strong belief in genotype by environment

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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).

interaction among farmers, (5) an interest in experimentation and (6) a belief in their ability to modify "foreign" seeds to suit their needs.

The basis of the local seed supply is the principle of saving one's own seed, which is embedded in the concept of "good farmer," explained above. As is well known, seed is not "transparent" (Morris 1998). This means that by looking at the seed before planting 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. Therefore there can be a major problem of information for the farmers. This problem is magnified by the facts that these farmers value multiple crop traits and different farmers require distinct varieties based on their needs, preferences and constraints, and that they believe that there is a high genotype-by-environment interaction. One could say hence, that in regards to maize varieties, "one size (variety) does not fit all." This is the reason that a diversity of maize varieties is maintained by these farmers in the first place (Bellon 1996). The problem of information is further exacerbated by the lack of a commonly recognized and clearly defined local nomenclature for local maize varieties that goes beyond broad categories such as grain color and width, and growing cycle. This problem originally identified by previous research in this area (Smale et al., 1999) has been confirmed by both Zapotec and Spanish speaking farmers from the study communities. For all these reasons, it makes perfect sense to keep one own seed. The seed is well known and it has the desired characteristics and performance both in terms of production and consumption requirements. These factors would suggest a very conservative behavior among farmers one it comes to accessing seed.

At the same time, farmers also recognize that there are other maize varieties that may be useful or desirable hence it is valuable to experiment with the seed from other farmers. An experiment allows a farmer to see for him or herself the traits and performance of the maize variety and judge whether it is appropriate for their needs and preferences, without incurring in major risks. At the same time farmers also share the belief that "foreign" varieties can be modified to suit one's own needs and preferences if one plants the seed in the appropriate environment and selects seed (a process known as *creolization*). These seeds also can 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 on farmers to access "foreign" seed, hence counterbalancing to a certain extent the conservative behavior described above. These principles translate into a resilient system, that is partly conservative, but that can innovate as well, and are consistent with the fact that seed flows usually involved small quantities of seed.

These factors also serve to explain seed transactions among farmers. Seed transactions are relatively infrequent and involve small quantities since one keeps one's own seed, but there are also motives to acquire seed. In order to do so, there is a need for accurate and trustworthy information. During focus group discussions and interviews it became clear that the easiest source of knowledge and trustworthy information, not surprisingly, is the people with whom the farmer already has close social relations. Often he or she 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 are growing were among the most frequently reported ways of obtaining information about seed from outside the household. It follows that the strategy of acquiring seed from relations of trust is in itself a way of reducing the risk of planting inappropriate seed. It should be stressed however, that while close social relations are an important, they are not the exclusive source of seed for farmers, and farmers do acquire seed from strangers.

The seed system in the study area seems to be grounded in cultural norms, which in themselves are based on the agroecological, cultural and social environments in which these farmers operate. An important finding is that the seed system is not a commercial one based on the search for profit maximization but rather, it is part of a moral system based on trust and social responsibility.

6. Implications for the conservation of genetic resources on farm

Farmers in the study area continue to maintain a diversity of maize landraces and contribute to the conservation of maize genetic diversity (Bellon et al. 2003; Smale et al. 2003). Research on the genetic structure of landraces collected in the study villages has shown no structure is present in these populations when neutral markers are analyzed, however when phenotypic traits are, there is a 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, i.e. 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, 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—compared to 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. Furthermore, experiments with these landraces have shown that there are high rates of deleterious mutations in them. Deleterious mutations are expressed in homozygous plants. Gene flow promotes heterozygous plants, hence mitigating the 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.

The results on genetic diversity are compatible with the results from the seed system in the study area presented here. First, the basis of the phenotypic diversity observed in the Central Valleys of Oaxaca is the farmers' practice of saving and selecting seed, which is the basis of the seed system. One could say that each farmer is creating and maintaining his or her own almost 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, as well as mix them with their own and creolized them. Third, gene flow may be also important to maintain the viability of these landraces in the face of deleterious mutations. The current seed system allows farmers to continue this process of experimentation and incorporation of new varieties into their repertoire.

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, either because they recuperate lost types or because they incorporate new valuable varieties or traits. Hence seed flows should be sustained. While it is true that farmers may choose to abandon maize agriculture, and hence the process that maintain diversity on farm, because they migrate to cities or to the USA or shift to other crops, the aging of the farming population, and the lack of interest among young people in agriculture, particularly if they are better educated, there are many farmers who still are interested in maize agriculture but their ability to continue may be diminishing due to increasing direct and indirect costs of obtaining seed (Bellon in press). Efforts to support on farm conservation should focus on these farmers.

Although a discussion of the interventions to support farmers to maintain genetic diversity on farm is beyond the scope of this paper and has been treated elsewhere (Bellon in press), the results presented here suggest that interventions to strengthen the local seed system may be fundamental and may involve fostering an information rich environment in which farmers know who is planting what and relevant and trustworthy information about the different varieties is available. Interventions that promote access to "new" interesting varieties to experiment at low cost and risks should be valuable, as was done during the CIMMYT/INFAP project. Any of such interventions should build trust,

which suggest that they should invest heavily on developing social capital among farmers and with the outsiders promoting the interventions.

7. Conclusions

The basis of the seed system analyzed here is the reliance of farmers on saved seed. Seed flows do occur, but only on relatively exceptional situations. Seed flows involve most of the time small quantities of seed, and probably are linked more to the exchange of information than to the exchange of physical seed. The system is resilience because there is a diversity of farmers facing different situations and conditions, but relatively few of them require seed from other farmers at any one time, mostly due to local failure or interest on experimentation, which means that other farmers are in a position to give seed to the requesting farmers. This system seems to be grounded in cultural norms that highlight trust and social responsibility rather than commercial considerations.

The present system seems resilient. Relatively few farmers need or request seed and this means that it is relatively easy to find somebody that can provide it. This situation however depends on the existence of a large population of farmers, if the number of farmers declines substantially the seed available for exchanges among them may diminish severely, jeopardizing the resilience of the system. This would require interventions that reinforce seed exchanges among farmers.

Currently, seed flows among farmers are relatively marginal, but the system could evolve towards more and larger quantities of seed moving among farmers, if the number of

farmers declines but the area planted per farmer increases. This could mean a step towards a more commercial system with less diversity (i.e. varieties) and more quantity of seed per variety. The nature of the seed system would then be changed dramatically.

References

Aguirre Gómez, J. A. 1999. Análisis regional de la diversidad del maíz en el Sureste de Guanajuato. Ph.D. thesis, Universidad Nacional Autónoma de México, México, D.F.

Aguirre, J.A., Aragón, F., Bellon, M., Berthaud, J., Smale, M. , 2002. CG Maize Diversity Conservation: A Farmer-Scientist Collaborative Approach. Final Technical Report. CIMMYT, Mexico, D.F.

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, 207-216.

Badstue, L., M. R. Bellon, J. Berthaud, X. Juárez, I. Manuel Rosas, A. M. Solano and A. Ramírez. 2003. Social relations and seed transactions among small-scale maize farmers: a case study from the Central Valleys of Oaxaca, Mexico. Submitted to Agricultural Systems.

Bellon, M. R. 1996. The dynamics of crop infraspecific diversity: A conceptual framework at the farmer level. Economic Botany 50, 26-39.

Bellon, M. R. and Risopoulos, J. 2001. Small-scale farmers expand the benefits of improved maize germplasm: a case study from Chiapas, Mexico. World Development 29, 799-811.

Bellon, M. R. in press. Conceptualizing interventions to support on-farm genetic resource conservation. World Development.

Bellon, M.R., Berthaud, J., Smale, M., Aguirre, J.A., Taba, S., Aragón, F., Díaz, J., Castro, H., 2003. Participatory landrace selection for on farm conservation: An example from the Central Valleys of Oaxaca, Mexico. Genetic Resources and Crop Evolution. 50, 401-416.

Bellon, M.R., J.L. Pham, and M.T. Jackson. 1997. Genetic conservation: A role for rice farmers. Pp. 263-289 in N. Maxted, B.V. Ford-Lloyd, and J.G. Hawkes (eds.), Plant Conservation: The In Situ Approach. London: Chapman and Hall.

Cordero Avendaño de Durand, C.1997. La Vara de Mando. Costumbre Jurídica en la Transmisión de Poderes. Biblioteca del 465 Aniversario, Oaxaca de Juárez, México.

Cromwell, E. (Ed.), 1990. Seed Difusion Mechanisms in Small Farmer Communities. Lessons from Asia, Africa, and Latin America. Odi-Network Paper 21. Overseas Development Institute, London, UK.

Hernandez, E. 1985. Maize and the greater Southwest. Economic Botany 39, 416-430.

INEGI (Instituto Nacional de Estadística, Geografía e Informática), 2001a. 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.

INEGI (Instituto Nacional de Estadística, Geografía e Informática) 2001b. XII Censo General de Poblacion y Vivienda. Http://www.inegi.gob.mx/difusion/espanol/poblacion/definitivos/oax/tabulados/ocot/25le01.pdf, last update 02/12/2002, 16:00.

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

Keller, L.F., Waller, D.M. 2002. Inbreeding effects on wild populations. Trends in Ecology and Evolution. 17(5): 230-241.

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

Morris, M. L. (ed.).1998. Maize Seed Industries in Developing Countries. Lynne Rienner Publishers, Boulder, Colorado.

Morris, M. and Lopez-Pereira, M. A. 1999. Impacts of Maize Breeding Research in Latin America 1966-1997. Mexico, D.F.: CIMMYT.

Perales-Rivera, H. R. Brush, S. B. and Qualset, C. 2003. Dynamic management of maize landraces in central Mexico. Economic Botany 57, 21-34.

Pressoir, G., Berthaud, J., 2003 Population structure and strong divergent selection shape phenotypic diversification in maize landraces. Heredity (in press).

Piperno, D.R. and K.V. Flannery. 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: 2101-2103.

Sanchez, J. J. G., C. W. Stuber and M. M. Goodman. 2000a. Isoenzymatic diversity in the races of maize in the Americas. Maydica 45:185-203.

Sanchez, J. J. G., M. M. Goodman and C. W. Stuber. 2000b. Isoenzymatic and morphological diversity in the races of maize in Mexico. Economic Botany 54:43-59.

Smale, M., Aguirre, A. , Bellon, M., Mendoza, J., Rosas, I. M., 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. CIMMYT, Mexico D.F.

Smale, M., M. R. Bellon, A. Aguirre, I. Manuel, J. Mendoza, A. M. Solano, R. Martínez and A. Ramírez. In press. The economic costs and benefits of a participatory project to conserve maize landraces on farms in Oaxaca, Mexico. Agricultural Economics.

Thiele, G., 1999. Informal Potato Seed Systems in the Andes: Why are they important and what should we do with them? World Development, 27, 83-99.

Wierema, H., Keune, L., Vermeer, R., Almekinders, C. 1994. Small-scale agriculture in Costa Rica, Nicaragua and Honduras. The rationality of local systems of seed supply. IVO Research report no. 43, Tilburg, The Netherlands.

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
% 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 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

Table 2. Reasons for acquiring maize seed

Theme	Total number of recorded seed acquisitions Reasons for acquiring seed (% of acquisitions)	317
Commencing to farm	**Commencing to farm**	**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**

Table 3. Quantity of seed involved in transactions

Total number of transactions[a]	421
Quantity of maize seed per transaction (kg)	% of transactions
□□	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

Table 4. Reasons for distributing seed

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