Seed procurement of native potatoes in the central Andes of Peru: the role of farmer-to-farmer exchange, markets and seed fairs

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Abstract

Procurement behavior of farmers and the role of farmer-to-farmer exchange, regular markets and seed fairs after normal and frost stressed years are compared. A series of surveys were applied in the department of Huancavelica (Peru), both during years with and without seed stress. During normal years seed acquisitions of native cultivars are characterized by transactions involving small quantities, few cultivars, few events of exchange, and seed flows over short distances. Most households exclusively use home produced seed of native cultivars. Uncommon native-floury and bitter cultivars are exchanged infrequently and only few farmers provide them. The capacity of the farmer seed system to annually widely supply and distribute infraspecific diversity is limited. Yet, at the household level, the farmer seed system is efficient at maintaining overall infraspecific diversity. Regular markets have a decentralized capacity to supply and widely distribute seed of selected cultivars. Frequencies of seed exchange at biodiversity seed fairs are low and involve small quantities of a few uncommon cultivars. The resilience of the farmer seed system to cope with severe regional seed stress (scarcity) is insufficient to be able to restore volumes and cultivar portfolios within a short period of time.

Keywords: farmer seed systems, seed stress, potato genetic diversity, Huancavelica.

Introduction

Seed systems are an interrelated combination of components involving diverse actors (farmers and organizations), production systems (planting materials, management options and storage), processes (distribution and access) and institutions (regulatory frameworks and informal rules). Farmer seed systems, also commonly referred to as informal, local or traditional seed systems, are particularly important for smallholder and poor farmers (Louwaars, 2007). In the Andean countries over 95% of the potatoes grown originate from farmer seed systems (Ezeta, 2001). The potato's cultivar diversity is almost exclusively multiplied through seed systems outside the formal regulation (De Haan *et al.*, 2009; De Haan and Thiele, 2004).

Seed procurement may be needed when home saved stocks do not balance a household's demand for seed in term of quantity, quality or cultivar content. The resulting seed flows are spatially determined routes of exchange (acquisition or provision) characterized by distance, volume, cultivar content, mechanism of exchange, source and destination. Seed flows generally cover limited distances (Thiele, 1999), but can cross international frontiers (Velásquez, 2002). Seed exchange can be farmer-to-farmer or arranged through organizations such as regular markets, biodiversity seed fairs, private or governmental agencies. Seed procurement often occurs through social networks which can be based on prestige and recognition, patron-client links or functional reciprocity. (Badstue, 2006; Badstue *et al.*, 2002; Richards, 2007; Tripp, 2001). While monetary exchange always involves sales, non-monetary exchange may include barter (*trueque*), payment in kind (*minka*) or presents (Ferraro, 2004; Mayer, 2002).

Rural markets in the Andes are a key meeting point for farmers where seed, food, animals, tools and other products are exchanged. Such markets have a long history throughout the Andes (Larson *et al.*, 1995); yet, little is known about their role in seed provision. Biodiversity seed fairs, on the other hand, are a relatively recent phenomenon. Since the first biodiversity seed fairs were organized in the late 1980´s the number of fairs organized by municipalities, governmental agencies and NGO´s has increased throughout Peru (Scurrah *et al.*, 1999). Currently, well over fifty biodiversity seed fairs are annually organized throughout the department of

Huancavelica alone. Typically a competition is central in the events as those participants who bring the largest number of cultivars are given a prize. Fairs are supposed to enhance the exchange of native cultivars among participants and visitors (Tapia, 2000; Tapia and Rosas, 1993).

Seed stress (scarcity) can be defined as the lack of sufficient quantities of seed of the desired quality or cultivars. Seed stress can be localized or regional, acute or chronic and caused by biotic or abiotic factors. However, potato seed stress in the Andes is generally localized, acute and caused by extreme weather events such as hail, frost or drought. On rare occasions acute seed stress may be a regional problem. Resilience refers to the seed systems ability to overcome seed stress, ultimately leading to a new equilibrium of desired seed stocks. Potentially, farmer responses to seed stress are diverse. Conventional channels of seed provision may be approached, including other farmers, markets or seed fairs. However, when seed stress is regional and severe, seed system interventions such as donations organized through government or development agencies may become increasingly important.

This article reports the functioning of farmer seed procurement of potatoes in a center of high infraspecific diversity (see: CIP, 2006). It particularly investigates the roles of farmer-to-farmer exchange, markets and seed fairs. Additionally, the study analyzes the impact of climate fluctuations in the form of out-of-season frosts on cultivar loss and seed procurement after seed stress (scarcity).

Materials and methods

A range of semi-structured surveys were applied in different communities within the department of Huancavelica, central Peru.

Survey of household seed exchange

A survey inquiring about 2003 and 2004 seed exchange (acquisition and provision) of native potato cultivars was conducted in 8 communities (n=125 households). Improved cultivars were not included in this particular survey. Each transaction was registered and detailed: cultivar composition, distance, volume, mechanism of exchange, source or destination. The 2002-2003 and 2003-2004 seasons were considered as "normal" production seasons by farmers: no severe regional events caused by drought, hail or frost had affected the potato crop.

Surveys of seed exchange at markets and seed fairs

In 2005, 9 regular markets in the department of Huancavelica were visited and 73 vendors surveyed (n=73). These markets were weekly and daily markets and selected on the basis of their regional recognized role as drivers of agricultural commerce. Individual transactions (n=183) involving seed provision during the 2005 dry season were detailed with vendors specifying cultivars and quantities sold. Additionally, between 2005 and 2006, 10 biodiversity seed fairs were visited and 76 participating farmers surveyed (n=76). The surveys inquired about all cultivar categories (improved, native-floury, native-bitter) and specific seed exchange transactions were detailed.

Survey of seed procurement after a severe frost

On February the 17th 2007 a severe frost affected potato cropping areas in central Peru (Los, 2007). It was an extreme and unusual event and as a consequence acute regional food and seed shortages were imminent. The central government declared Huancavelica, among other departments, an emergency zone. This created a special situation in which regional governmental offices received the mandate and resources to provide seed and food to the affected communities. This shock to the seed system presented itself as a natural experiment to understand resilience. A large survey was conducted at the start of the 2007 - 2008 cropping season to characterize potato seed procurement after the extreme event. The survey involved households (n=280) from 10 communities from central Huancavelica.

Results

Seed exchange during years without seed stress

Of the farmers (n=124) interviewed about seed exchange of native potato cultivars (both native-floury and native-bitter), 41.1 % indicated to exclusively use home-produced seed of native cultivars. The frequencies of partial seed stock renewal vary among farmers: 18.5% of the farmers renew part of their seed stock yearly, 17.7% every two years, 8.9% every three years, and 12.6% every four to six years. Complete renewal of seed stocks is uncommon, even of single cultivars. Households acquiring seed from elsewhere do so to add seed to their home saved stocks.

More households provided (42.4% in 2003, 52.8% in 2004) rather than acquired (21.0% in 2003, 29.6% in 2004) seed of native cultivars during both year of inquiry. The annual number of transactions involving provision was always higher compared to events involving acquisition. Most households acquiring seed did so only once a year (84.9%); only few households were involved in two (13.7%) or three (1.5%) annual transactions to acquire seed. While most households providing seed of native cultivars were only involved in a single annual transaction of provision (59.9%), a comparatively high proportion of households was involved in two (29.6%), three (8.8%) or four (1.8%) transactions. Farmers looked for seed of new (60.3%) or lost (41.1%) native cultivars, rather than for common cultivars already in stock (19.1%) when they acquire seed. Yet, when it came to provision, 67.6% of farmers provided commercial rather than uncommon native cultivars.

Quantities of seed acquired were relatively small with an average of 25.3 and 69.5 kg per household for 2003 and 2004 respectively (table 1). Depending on the community this represents a minimum of 0.8% and a maximum of 7.7% of the annual household need for seed. Between 86.2% (2003) to 96.2% (2004) of the acquisitions of native cultivars involved less than 100 kg. Quantities of seed provided were higher than those acquired, with an average of 372.7 and 489.0 kg per household for 2003 and 2004 respectively. Between 43.2% (2003) and 54.3% (2004) of the seed provisions of native cultivars involved more than 100 kg.

Table 1. Quantities of seed of native potato cultivars acquired and provided by households

Year	Flow	N	Distribution: volume exchanged (%)						Weight (kg)			
			< 5 kg	5-25 kg	25-100 kg	100-500 kg	500-1000 kg	> 1000 kg	Av.	SD (±)	Min	Max
2003	Acquired	27	29.6	37.0	29.6	3.7	-	-	25.3	28.0	0.5	120
	Provided	51	2.0	17.6	37.3	27.5	11.8	3.9	372.7	977.2	3.0	6700
2004	Acquired	36	16.7	41.7	27.8	11.1	2.8	-	69.5	134.9	0.4	600
	Provided	59	1.7	10.2	33.9	39.0	11.9	3.4	489.0	1826.8	2.0	14000

The average number of native cultivars being exchanged by households as seed was relatively low (table 2). In 2003 surveyed households (n=125) acquired and provided a total of 25 and 28 different cultivars while in 2004 households acquired and provided 57 and 34 different cultivars respectively. During both years most cultivars showed low frequencies of exchange and were consequently only acquired or provided by a single household (table 3). These were generally non-commercial native-floury cultivars preferred for home consumption. Without exception those native cultivars with high frequencies of exchange were well-known cosmopolitan cultivars for renewal of commercial seed stocks.

Table 2. Average number of native cultivars exchanged per transaction

Year	Flow	N[1]	Av.	SD (±)	Min.	Max.[2]
2003	Acquired	27	3.7	3.7	1	10
	Provided	53	5.8	3.8	1	10
2004	Acquired	36	3.5	2.5	1	10
	Provided	66	5.4	3.7	1	10

[1] = number of registered transactions; [2] = based on average cultivar content of complete cultivar mixtures (*chaqru*)

Table 3. Total number of native cultivars exchanged by relative frequencies of exchange

Frequency	2003				2004			
	Acquired		Provided		Acquired		Provided	
	No.	%	No.	%	No.	%	No.	%
Low freq. of exchange (1)	17	68.0	12	42.9	39	68.4	17	50.0
Medium freq. of exchange (2-5)	7	28.0	9	32.1	13	22.8	9	26.5
High freq. of exchange (>5)	1	4.0	7	25.0	5	8.8	8	23.5
Total	25	100	28	100	57	100	34	100

Family members and farmers, as well as regular markets and yearly agricultural fairs, were reported to be important sources and destinations for seed exchange of native cultivars during both periods of inquiry (table 4). Farmers did not consider governmental and development organization important sources of seed during these years without regional seed stress. Exchange through sales was the most frequently used mechanism of seed acquisition and provision, followed in importance by presents, barter and payment in kind (fig. 1). Other mechanisms such as loans to and from other farmers or donations from organizations were infrequent. Sales generally involved larger volumes of a limited number of cultivars while presents mostly related to small volumes containing diverse cultivars.

Table 4. Commonly used sources for seed exchange of native potato cultivars (n=72)

	Acquisition (%)	Provision (%)
Family member from the same community	27.8	43.1
Farmers from the same community	18.2	27.8
Farmers from other communities	22.2	26.4
Regular markets / agricultural fairs in other communities	44.4	43.1
Seed company	2.8	-
Others	2.8	1.4

Most of the 2003 (85.7%) and 2004 (74.4%) seed acquisitions originated from within the provincial boundaries of the 7 provinces that constitute the department of Huancavelica. A similar pattern can be observed for seed provision with 84.6% and 88.8% of the 2003 and 2004 transactions ending up within the province where the seed had been produced . On average only 11.8% of the transactions passed provincial limits, yet remained within the department of Huancavelica. Exchanges exceeding departmental boundaries only represented 6.5% of the total number of transactions. On average seed flows covered distances ranging between 15.2 and 49.4 km, depending on the process (acquisition or provision) and year (2003 or 2004). Yet, when looking at frequencies (%), most transactions covered less than 25 km (table 5). Only 5.5% of the total number of seed exchanges covered right-angle distances of more than 100 km.

Table 5: Distances (right-angle) covered by individual seed flows

Year	Process	N	Distribution: distances seed exchange (%)						Distance (km)			
			< 1 km	1-5 km	5-25 km	25-100 km	100-200 km	> 200 km	Av.	SD (±)	Min	Max
2003	Acquired	29	41.4	6.9	34.5	17.2	-	-	15.7	25.7	0.2	98
	Provided	79	26.6	7.6	50.6	11.4	2.5	1.3	18.0	36.4	0.2	258
2004	Acquired	44	29.5	6.8	43.2	4.5	9.1	6.8	49.3	112.5	0.2	528
	Provided	96	29.2	2.1	55.2	11.5	2.1	-	15.2	21.9	0.2	134

The role of regular markets

A range of vendors (n=73) at daily and weekly regular markets were interviewed, including wholesalers (38.4%) and retailers (61.6%). Wholesalers were typically able to provide at least a quarter of a ton of potatoes if demanded while retailers provided relatively small quantities. Overall, 68.8% of vendors were also potato producers. An average of 23.3% of vendors only sold potatoes they themselves produced, while 39.7% only traded potatoes they bought from other farmers and 37.0% provided both self-produced and purchased potatoes. An average of 61.1% of vendors sold potatoes produced in the department Huancavelica. The proportion of produce from Junín was appreciable with an average of 38.9% of vendors providing potatoes originating in this department.

An average of 63.0% of the vendors sold both improved and native cultivars while only 34.2% and 2.7% sold exclusively improved or native cultivars respectively. The total infraspecfic diversity offered at regular markets was relatively low with an average of 4.6 and a maximum of 8.0 cultivars per vendor. The most commonly available cultivars, both in terms of volume and number of vendors offering them, were: *Yungay*, *Canchan*, *Larga*, *Wayru*, *Amarilla Runtus*, *Andina*, *Perricoli*, *Camotillo* and *Peruanita*. An average of 11.1% of the vendors sold complete cultivar mixtures (*chaqru*). Depending on the cultivar, average prices fluctuated between 0.55 and 1.80 Peruvian Soles per kg (0.17 - 0.54 US dollars in the survey year). Few vendors (1.4%) also offered fresh (non-processed) tubers of native-bitter cultivars.

Vendors recalled seed transaction on the basis of demand: transactions based on the client explicitly requesting seed instead of consumption potatoes. Depending on the market, 46.7% to 100% of the vendors sold potato seed in addition to trading consumption potatoes. Averaged over all markets, 63.0 % of the vendors sold seed. The Saturday market in Yauli was the only exception as none of the vendors sold seed. Those vendor who did sell seed during the 2005 dry season, did so providing seed to an average of 8.8 (± 6.4) farmers (min. 1 / max. 25). Most vendors (66.7%) typically provided less than 50 kg of seed per individual transaction while only few vendors provided between 50 to 100 kg (20.0%) and 100 to 500 kg (11.1%). Sales involving more than 500 kg of seed were uncommon (2.2%).

An average of 56.4% of the vendors exclusively sold tubers of consumption potatoes as seed without any kind of selection or formal guarantee. A small number of vendors (15.4%) exclusively offered selected tubers of what is commonly known as "*semilla común*" (common seed: reselected tubers from stocks of consumption potato without any guarantee accrediting quality). Selection of "*semilla común*" is predominantly based on tuber-size and external (visible) seed health. An average of 28.2% of vendors sold both consumption potatoes and selected tubers as seed.

A total of 389 individual seed transactions from 46 vendors to farmers were registered; 183 were detailed by vendors (table 6). The transactions detailed involved more than 27 cultivars (8 improved; 19 native-floury including *chaqru* mixtures) and a total volume of 57,392 kg (36,617 kg improved; 20,775 kg native-floury). These transactions, to be used for the 2005-2006 agricultural season, served a total of 63 farmer communities covering all 7 provinces of the Huancavelica department. Extra-departmental seed flows from regular markets in Huancavelica were limited, representing only 2 out of 63 registered destinations and 4.0% of the total number of transactions.

The details of seed transactions show that native-bitter cultivars were not traded as seed (no transaction were registered). The 8 cultivars offered by most vendors (> 10%) are well-known cosmopolitan improved (4) and native-floury (4) cultivars which are also commonly found in urban markets of Huancayo and Lima. The number of transactions involving seed sales of these cultivars and the quantities sold are considerably higher compared to the other cultivars. Out of the 15 cultivars offered by very few vendors (< 5%), 12 are little-known native-floury cultivars of regional importance. The other 3 are improved cultivars which have gone out of demand as commercial ware potatoes (*Renacimiento*, *Revolución*) or have only been released recently (*Unica*). Only a single transaction was registered for 10 out of the 15 cultivars offered by few vendors. In all cases their traded volume was relatively low compared to cosmopolitan cultivars. The foregoing indicated that only limited infraspecific diversity is being offered at regular markets, with few samples and small quantities of little-known cultivars being traded infrequently by selected vendors. An interesting exception are the complete cultivar mixtures (*chaqru*). *Chaqru* seed was offered by 9.3% of the vendors, involving 10 transactions averaging 128 kg each.

Table 6. Details of individual seed transactions (n=183)

Cultivar	%[1]	Cultivar Category		No. specific transactions registered (n)	Amount Sold (Kg.)			
		IC[2]	NFC[3]		Av.	SD (±)	Min.	Max.
'Amarillis'	14.0	X		7	371	243	100	700
'Amarilla Runtus'	7.0		X	12	169	145	50	500
'Andina'	14.0	X		10	573	1207	80	4000
'Ajo Suytu'	2.3		X	3	163	118	90	300
'Camotillo'	18.6		X	6	198	172	40	500
'Canchan'	58.1	X		26	620	1569	50	8000
'Casa Blanca'	2.3		X	1	100	-	-	-
Chaqru (*)	9.3		X	10	128	71	30	200
'Chaulina'	2.3		X	1	50	-	-	-
'Chunya'	4.7		X	1	24	-	-	-
'Huanuqueña'	2.3		X	1	50	-	-	-
'Kuchipa Akan'	2.3		X	1	18	-	-	-
'Larga'	51.2		X	24	183	200	30	800
'Perricholi'	7.0	X		4	145	95	50	250
'Peruanita'	30.2		X	20	324	462	40	2000
'Puqya'	2.3		X	2	38	3	36	40
'Renacimiento'	2.3	X		1	40	-	-	-
'Revolución'	2.3	X		1	200	-	-	-
'Saco Largo'	2.3		X	1	200	-	-	-
'Traqin Waqachi'	4.7		X	4	110	60	80	200
'Tumbay'	2.3		X	2	250	212	100	400
'Unica'	2.3	X		1	900	-	-	-
'Villa'	7.0		X	2	95	7	90	100
'Wayru'	18.6		X	12	299	614	30	2200
'Wayta Chuko'	2.3		X	1	40	-	-	-
'Witqis'	2.3		X	2	16	20	2	30
'Yungay'	62.8	X		27	372	773	12	4000

[1] = percentage of vendors selling the particular cultivar; [2] = improved cultivars; [3] = native floury cultivars; * *Chaqru* = a mix of native-floury cultivars

The role of seed fairs

Every year numerous quite festive biodiversity seed fairs are organized throughout Huancavelica. Of the interviewed farmers who participated in the 10 fairs that this study looked at, 21.9% participated for the first time, while 46.6% had participated for at least four or more years in the same fair. While 28.8% only participated in a single fair a year, many participated in two (32.9%), three (13.7%), four (16.4%) or more (8.2%) annual seed fairs. About three quarters of the farmers (72.6%) knew some of the other participants at the same fair and most of these (69.9%) returned on a yearly basis, suggesting that participants are a select group of farmers who are well-known to each other. This impression is supported by the finding that most farmers (61.6%) considered that only few new participants were observed at the fairs. Farmers knew about the event because they received an invitation (82.2%), heard about it on the radio (31.5%), were notified by other farmers (12.3%) or neighbors (4.1%), or remembered the place and date from previous years (1.4%). Farmer's personal motivations to participate in fairs were diverse and included: demonstrate their cultivars (45.2%), recognition for the home community (32.9%), win a prize (27.4%), personal recognition (21.9%), comply with invitation (19.2%), obtain new cultivars (15.1%), obtain new knowledge (11.0%), and recognition for the family (6.8%).

Of the farmers interviewed, 68 participated with native potato cultivars only whereas 5 farmers exclusively participated with improved cultivars. Participants typically showed 5 to 10 tubers of each cultivar. Farmers

participating with native cultivars (n=68) on average presented 123 cultivars per family collection (n=68). Few farmers presented less than 25 cultivars (4.4%). Other farmers presented 25 to 50 (29.4%), 50 to 100 (26.5%), or 100-200 distinct cultivars (25.0%). A select group of farmers (14.8%) presented family collections consisting of more than 200 cultivars. A total of 86.0% of the respondents indicated that their cultivar variability was a family inheritance while only 14.0% had obtained most cultivars through exchange.

Participant perception indicates that seed exchange at the seed fairs is not common; 60.0% considered that none, 23.3% that few and only 15.7% that some farmers exchange seed at the events. A total of 14.3% of respondents indicated that biodiversity seed fairs could potentially be important events for exchange, but that in practice this does not occur because of competition. An average of 76.6% of respondents considered that farmers participating in the fairs are generally "*celoso*" (jealous) with their seed, meaning that these farmers will not exchange in order to maintain a comparative advantage over other competitors and thereby increase their likelihood to win a prize. When asked about their willingness to exchange seed, 37.7% indicated they would not exchange seed of any cultivar, 23.2% they would be willing to exchange any of their cultivars, and 39.1% they would only exchange well-known cultivars.

An average of 21.1% of participants had acquired seed while 27.8% had provided seed at the 10 fairs where surveys were conducted. Depending on the fair, the percentage of farmers having acquired or provided seed fluctuated between 0 - 66.7% and 0 - 50.0% respectively. Not only do few farmers exchange seed, those who exchange generally do so with few cultivars (av. 5.3, min. 1, max. 10) and small volumes (1 to 5 tubers or 1 to 12 kg per cultivar). Most look for new cultivars at the fairs. An average of 35.6% of participants indicated that the fairs had allowed them to increase cultivar diversity. The most common mechanism of exchange was through sales, followed by barter. A few farmers (4.2%) also mentioned they would try and steal some seeds if they could.

Impact of frost and responses to seed stress

The severe frost that affected the central Peruvian highlands on February the 17th 2007 caused significant crop damage in Huancavelica. In the surveyed communities the frost affected 92.6 to 95.8% of the potato fields. The measured minimum temperature was -4ºC. Fields on flat, non-sloping terrain were particularly hard hit as cold air tends to go downhill and settle where it reaches valley bottoms. Regional levels of yield reduction ranged from a minimum of 70.4% (native-bitter cultivars) to a maximum of 77.2% (mixed stands of native-floury cultivars) showing that general differences between the cultivar categories was minimal.

An average of 75.1% of farmers reported cultivar loss. Loss varied for the different cultivar categories, ranging from 15.4% for native-bitter cultivars to 69.3% for native-floury cultivars, indicating that cultivar loss was proportionally more severe for the diverse cultivar category of native-floury cultivars. On average farmers lost 4.7 cultivars. The average number of cultivars lost was higher for the category of native-floury cultivars (4.3 cultivars lost) compared to improved and native-bitter cultivars (1.3 and 1.2 cultivars lost respectively). Farmers prioritized 5 main reasons for cultivar loss (n=241): cultivars were installed on flat terrain (71.8%), cultivars were susceptible to frost (55.2%), cultivars were already scarce and not abundant in fields (11.2%), cultivars were installed at exceptionally high altitude (10.0%), and the frost was exceptionally severe (6.2%).

An average of 23.3% of farmers lost all potato seed (table 6.14). However, levels of total seed loss differed considerably by community. While a majority of the farmers (69.2%) from the community Pucara lost all their seed none of the farmers from Huachua suffered the same fate. For those farmers who were able to save seed, the volumes stored were low compared to normal years. Overall, farmers only saved about a quarter (25.2%) of the amount of seed they would store during a normal year, evidencing severe seed stress. A total of 97.8% of the farmers also indicated that the frost had affected seed quality: smaller seed size (71.2%), rotting (19.6%), tuber skin damage (11.1%), blackening (5.9%) and higher levels of damage from larvae of Andean weevil (5.5%; *Premnotrypes* spp.) were reported. The later is a consequence of farmers having limited choice and therefore having to include seed with recognized pest damage.

High levels of yield reduction together with cultivar loss explain the need for farmers to acquire seed. A total of 83.2% of the families interviewed for the survey (n=279) had been able to acquire potato seed. An average of 42.5% of combined seed acquisitions for individual households was exclusively coordinated by men, 17.4% exclusively by women and 40.1% by both sexes. Of those farmers having reported cultivar loss 23.6% had not been able to recuperate any of the lost cultivars for the next planting season, 75.3% had recuperated some cultivars, while only 1.1% had been able to acquire all the cultivars they lost.

On average households acquired seed from 2.3 (± 1.3) different sources; some had acquired seed from up to 9 different sources. Table 7 provides an overview of the relative importance of specific mechanisms of seed acquisition in 2007 after the frost: donations, monetary acquisition and non-monetary acquisition. Seed from government donations were the most important source of seed in terms of the number of families having benefited from this mechanism (42.9%), followed in importance by monetary acquisitions from regular markets, monetary acquisitions at agricultural fairs, and non-monetary acquisitions through *minka* (payment in kind). It is interesting to note that each of the ten communities had its own unique portfolio and combinations of mechanisms for seed acquisition. While some mechanism were of no importance in some communities they were relevant in others.

The volume and cultivar content of 574 individual seed acquisitions realized by 253 different households was registered. Table 8 shows summarized information of the quantities of seed acquired per event of exchange. Very few transactions involving native-bitter cultivars were registered, affirming that sources of supply of this cultivar category are scarce. Each seed acquisition involved on average 66 kg. Yet, a high standard deviation indicates that there were considerable differences in the quantities of seed exchanged per transaction. Overall, farmers acquired slightly more seed of native-floury cultivars (279 transactions; av. 81 kg / transaction) as compared to improved cultivars (286 transactions; av. 53 kg / transaction). Differences between communities concerning the average amount of seed acquired per transaction were modest; the community of Sotopampa was the only notable exception.

Most households acquired seed of diverse cultivar categories: improved and native-floury cultivars. The registered acquisition of improved cultivars was limited to 5 cultivars: *Yungay* (58.5%), *Canchan* (27.6%), *Perricholi* (12.2%), *Tomasa* (1.0%) and *Mariva* (0.7%). Farmer acquisition of native-bitter cultivars was rare and only involved 2 cultivars: *Siri* (55.6%) and *Manwa* (44.4%). The acquisition of native-floury seed was characterized by higher levels of diversity with 40 cultivars registered. As expected, common commercial cultivars were most commonly acquired: *Larga* (23.9%), *Wayru* (7.4%), *Peruanita* (7.0%) and *Amarilla Runtus* (6.0%). The acquisition of mixed seed lots (*chaqru*) represented only 7.0% of the total number of individual seed acquisitions of native-floury cultivars. The average total number of cultivars acquired per household was 3.0 (± 2.8;). This means that although most farmers were able to acquire seed, the overall diversity acquired was modest with relatively few farmers having obtained mixed seed lots and the overall acquired diversity consisting of few distinct cultivars. Nevertheless, most farmers (41.7%) did acquire seed of different cultivar categories; improved cultivars predominantly via donations and native-floury cultivars through monetary acquisitions at markets and fairs or through *minka*.

Table 7. Relative importance (*) of different mechanisms of seed acquisition between May - December 2007, right after the season with severe frost

Community	N¹	Donation (%)			Monetary Acquisition (%)					Non-Monetary Acquisition		
		GO	NGO	Family	Regular Markets	Agricultural Fairs	Family	Farmer from the community	Farmer from another community	Loan	Barter	*Minka*: payment in kind
Pucara	26	35.7	-	-	17.9	67.9	-	3.6	3.6	-	-	-
Villa Hermosa	19	68.4	-	10.5	-	78.9	-	-	-	-	-	-
Chuñunapampa	20	60.0	5.0	-	30.0	15.0	5.0	-	-	5.0	-	40.0
Sotopampa	25	96.0	16.0	-	4.0	-	16.0	12.0	4.0	-	8.0	40.0
Ccasapata	24	59.1	4.5	-	40.9	-	18.2	13.6	4.5	-	-	18.2
Santa Rosa	25	-	-	-	4.0	28.0	24.0	4.0	-	-	-	44.0
Ccollpaccasa	25	4.0	4.0	-	40.0	48.0	12.0	12.0	4.0	-	-	8.0
Huachua	22	59.1	4.5	-	40.9	4.5	22.7	4.5	-	-	-	45.5
Chopccapampa	50	12.0	2.0	-	86.0	4.0	6.0	26.0	2.0	-	6.0	-
Limapampa	25	80.0	8.0	-	24.0	32.0	20.0	4.0	8.0	-	-	36.0
Overall	*261*	*42.9*	*4.2*	*0.8*	*34.5*	*25.7*	*11.9*	*10.0*	*2.7*	*0.4*	*1.9*	*20.7*

* = the percentage of households having acquired seed through any of the specific mechanisms; ¹ = No. of households

Table 8. Quantities of seed exchanged per acquisition between May - December 2007, right after the season with severe frost

Community	Potato overall (kg)					Improved cultivars (kg)					Native-floury cultivars (kg)					Native-bitter cultivars (kg)				
	N¹	Av.	SD	Min.	Max.	N¹	Av.	SD	Min.	Max.	N¹	Av.	SD	Min.	Max.	N¹	Av.	SD	Min.	Max.
Pucara	50	52	35	10	155	45	51	35	10	155	5	60	38	25	100	0	-	-	-	-
Villa Hermosa	60	55	31	10	150	43	55	31	10	150	17	55	32	10	100	0	-	-	-	-
Chuñunapampa	38	66	64	2	350	13	64	38	15	150	24	69	76	2	350	1	15	0	15	15
Sotopampa	50	188	686	5	3500	31	49	58	5	285	19	413	1090	5	3500	0	-	-	-	-
Ccasapata	42	49	34	1	150	20	58	32	10	150	21	39	32	1	100	1	100	0	100	100
Santa Rosa	58	46	24	5	150	6	38	18	15	50	51	48	25	10	150	1	10	0	10	10
Ccollpaccasa	76	53	50	5	250	21	45	39	5	150	50	57	56	5	250	5	46	9	30	50
Huachua	63	75	183	3	1000	16	43	35	5	100	47	86	210	3	1000	0	-	-	-	-
Chopccapampa	91	55	47	5	200	61	63	48	5	200	30	40.0	41	5	150	0	-	-	-	-
Limapampa	46	40	35	5	200	30	46	38	10	200	15	31	26	5	100	1	5	0	5	5
Overall	*574*	*66*	*216*	*1*	*3500*	*286*	*53*	*41*	*5*	*285*	*279*	*81*	*307*	*1*	*3500*	*9*	*40*	*29*	*5*	*100*

¹ = Number of individual seed acquisitions

Conclusions

During years without extreme regional events affecting the overall productivity of potato, seed acquisitions of native cultivars are characterized by transactions involving small quantities of seed, few cultivars, few events of exchange, and movements of seed over short distances within communities and provinces. Annual seed acquisitions of native cultivars were practiced by 25% of the households. So, most households exclusively use home produced seed of native cultivars while those acquiring seed do so to partially renew their seed stocks. About half (48%) of the households in the studied communities provide seed and do so more frequently than acquiring seed. Seed provisions also involve larger volumes and distances compared to seed acquisitions. All this suggests that high-altitude and diversity-rich communities are net seed exporters rather than importers of native cultivars during normal years. Seed acquisitions and provisions during normal years typically involve diverse sources including markets, fairs, family and other farmers rather than governmental or non-governmental agencies. Exchange through sales is predominant, but transactions through barter, gifts and payment in kind are also important. It is likely that the socioeconomic conditions of farmers in terms of poverty and availability of cash influence the seed exchange mechanisms they can access.

Even during normal years, uncommon native cultivars are exchanged infrequently and only few farmers provide them. The former contradicts common farmer interest as many look for new or lost cultivars rather than for common cultivars already in stock. It also contradicts the common notion that informal networks of seed exchange are very dynamic. Collectively, communities in Huancavelica maintain at least 500 genetically and morphologically distinct native cultivars (see: CIP, 2006; De Haan, 2009). The maximum total annual regional amount of distinct cultivars being exchanged was 57 (seed acquisition 2004); this translated into 11% of the total cultivar diversity. Most are native-floury rather than native-bitter cultivars. The latter are almost exclusively maintained and reproduced at the household level. Uncommon native-floury cultivars are not actively marketed by farmers who maintain them. However, households wishing to acquire diverse native-floury cultivars have a chance to do so when they know the right specialist channels, such as vendors providing *chaqru* at markets or farmers willing to exchange. The participation of the formal regulated system in seed exchange of native cultivars is minimal. This study shows that the efficiency of the farmer seed system in terms of its capacity to annually widely supply and distribute infraspecific diversity is restricted. However, in the long run, the farmer seed system generally seems efficient at maintaining overall infraspecific diversity at the household level. This is supported by the fact that no evidence of genetic erosion exists and that farmers in Huancavelica still maintain early-generation improved cultivars disseminated in the 1950's.

Regular markets typically provide relatively large volumes of seed of selected improved and native-floury potato cultivars rather than infraspecific diversity. Exchanges of these well-known cultivars are frequent and involve large quantities. Market originating seed flows have a wide outreach, covering all provinces within Huancavelica. Indeed, the strength of regular markets as seed suppliers resides in their decentralized capacity to supply and widely distribute selected cultivars with commercial demand while their weakness resides in the limited infraspecific diversity and quality guarantee they offer. Uncommon cultivars are typically only offered by a few vendors while their transactions are infrequent involving small quantities of seed. Complete native-floury cultivars mixtures (*chaqru*) are offered by a few selected vendors while seed of native-bitter cultivars are generally unavailable. Regular potato markets in the rural areas of central Peru are mostly consumption markets rather than specialized seed markets.

Biodiversity seed fairs are an institutional innovation which potentially changes the way in which transactions occur. The original intention of the fairs was to enhance broad diffusion of native cultivars among farmers. Indeed, contemporary fairs almost exclusively target native-floury and native-bitter cultivars. However, findings of this research suggest that the biodiversity seed fairs are not necessarily doing what they were designed for. Participation at the fairs is often restricted to a select group of recognized farmers. Seed exchange is not an important motive for farmers to participate. Rather, it is prestige, recognition or the possibility of winning a prize which motivates participants. In practice, the frequencies of seed exchange are low. Not only do few farmers exchange seed, those who exchange generally do so with a few uncommon cultivars and small volumes. The number of cultivars and volumes exchanged, though potentially interesting for a collector, are generally not significant for those wishing to acquire seed for planting large areas. The strength of biodiversity seed fairs resides in the impressive amount of native cultivars farmers put on display. Seed fairs are an excellent thermometer to monitor overall genetic diversity. Yet, their weakness resides in selectiveness toward individuals rather than farmers communities and incapacity to create an environment which stimulates seed exchange.

Organizers of fairs could promote wider participation and seed exchange by emphasizing the participation of communities rather than individual farmers, including indicators of seed exchange into the evaluation criteria, and by providing incentives for most participants rather than for the top-three "conservationist" farmers alone.

Inquiry into the dynamic seed system response to seed stress provides diverse lessons. The 2007 February frost severely affected productivity of the potato crop and led to seed stress as a result of the loss of cultivars and acute shortages of planting material. Cultivar loss was predominantly a consequence of severe crop failure rather than farmers not being able to save seed from being consumed. Contrary to normal years, when seed acquisitions from governmental organizations were of little importance for farmers, state-organized donations were regionally the most important source of seed after the frost. Governmental organizations reached numerous communities and households with donations. This in itself does not necessarily imply that the farmer seed system was unable to cope with seed stress. Rather, it reaffirms that external emergency interventions often assume that seed availability is the main problem after a severe shock, discounting the possibility that local channels can supply good quality seed (McGuire, 2007). In practice, regular markets, agricultural fairs, payment in kind (*minka*), acquisitions from family and community members remained important sources of seed. These sources are also commonly used during normal years, but became more important during the period with seed stress. Each community showed a unique portfolio and combination of mechanisms of seed acquisition. Indeed, in all communities a diversity of mechanisms were employed to regain seed. Considering the regional shortage of planting material, the frequency of seed exchanges and sources used suggest impressive resilience of the farmer seed system. The system was, at least partially, able to attend local demands within the first year after the stress and restore part of the cultivar portfolios of individual households.

An average farmer in the studied communities annually dedicates an area of 5,609 m² to potatoes (see chapter 4). This translates into a minimal annual demand of 1,400 kg of seed. In 2007, after the season with severe frost incidence, the average household only saved 25.2% of the potato seed they would normally store. This means a minimum of 350 kg per household and an average household deficit of 1,050 kg. On average households acquired seed from 2.3 different sources, exchanging 66 kg per transaction. The average household thus acquired 152 kg of seed, leaving an overall deficit of 898 kg representing 64% of the total demand. This simple calculation shows that for many households the amount of seed acquired after the frost must have been insufficient to meet the normal demand, even though the real seed deficit may have been less and differences between households exist. This suggests that both the government donations and the regional farmer seed system were both unable to provide sufficient quantities of seed. In addition, government and other organizations donated mostly seed of improved cultivars Information about seed quality and exact origin was not available to farmers. The government's incapability to provide farmers with clear information about the origin of donated seed fomented suspicions from farmers. Resilience of the farmer seed system was incomplete as households were only able to restore part of their original seed stocks, both in terms of volumes and cultivar portfolios. Indeed, several seasons may be needed for households to fully recover their seed stocks. This also means that repeated regional shocks may impede the seed system to fully recover.

Literature cited

Badstue, L.B. 2006. Smallholder Seed Practices: maize seed management in the central valleys of Oaxaca, Mexico. PhD Thesis. Wageningen University, Wageningen.

Badstue, L.B., Bellon, M.R., Juárez, X., Manuel, I., and Solano, A.M. 2002. Social Relations and Seed Transaction among Smallscale Maize Farmers in the Central Valley of Oaxaca, Mexico. Economics Working Paper 02-02. International Maize and Wheat Improvement Center (CIMMYT), Mexico.

CIP (ed.), 2006. Catálogo de Variedades de Papa Nativa de Huancavelica - Perú. Centro Internacional de la Papa (CIP), Federación Departamental de Comunidades Campesinas de Huancavelica (FEDECCH), Lima.

De Haan, S. 2009. Potato Diversity at Height: multiple dimensions of farmer-driven *in-situ* conservation in the Andes. PhD thesis. Wageningen University, Wageningen.

De Haan, S. and Thiele, G. 2004. *In-situ* conservation and potato seed systems in the Andes. pp. 126-132. In: D.I. Jarvis, R. Sevilla-Panizo, J.L Chavez-Servia and T. Hodgkin, T. (eds.), Seed Systems and Crop Genetic Diversity On-Farm, proceedings of a workshop (Pucallpa, Peru, 16-20 September 2003), Rome.

Ezeta, F.N. 2001. Producción de semilla de papa en Latinoamérica. Revista Latinoamericana de la Papa 12:1-14.

Ferraro, E. 2004. Reciprocidad, Don y Deuda: formas y relaciones de intercambio en los Andes de Ecuador. FLACSO, Abya-Yala, Quito.

Larson, B., Tandeter, E., and Harris, E. 1995. Ethnicity, Markets, and Migration in the Andes: at the crossroads of history and anthropology. Duke University Press, Durham.

Los, P. 2007. Lo que "El Niño" dejó en la sierra central del Perú. Volveré IV(26), www.unap.cl/iecta/revistas/volvere_26/articulo_1_volvere_26.htm (visited: 02-10-09).

Louwaars, N. 2007. Seeds of Confusion: the impact of policies on seed systems. PhD Thesis. Wageningen University, Wageningen.

Mayer, E. 2002. The Articulated Peasant: household economies in the Andes. Westview Press, Boulder.

McGuire, S. 2007. Vulnerability in farmer seed systems: farmer practices for coping with seed insecurity for sorghum in eastern Ethiopia. Economic Botany 61(3):311-222.

Richards, P. 2007. Farmers first?: toward a neural network perspective on farmer seed systems. Paper presented at the "Farmers First Revisited" workshop (University of Sussex, 12-14December 2007), www.future-agricultures.org/farmerfirst/files/T3b_Richards.pdf (visited: 17-06-08).

Scurrah, M., Fernandez-Baca, E., Ccanto, R., Nunez, E., Olivera, E., and Zúñiga, N. 1999. Learning about biodiversity in Peru. ILEIA Newsletter 15(3-4):26-28.

Tapia, M.E. 2000. Mountain agrobiodiversity in Peru: seed fairs, seed banks, and mountain-to-mountain exchange. Mountain Research and Development 20(3):220-225.

Tapia, M.E. and Rosas, A. 1993. Seed fairs in the Andes: a strategy for local conservation of plant genetic resources. pp. 111-118. In: W. de Boef, K. Amanor, K. Wellard and A. Bebbington (eds.), Cultivating Knowledge: genetic diversity, farmer experimentation and crop research, Intermediate Technology Publications, London.

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

Tripp, R. 2001. Seed Provision & Agricultural Development, Overseas Development Institute, London.

Velásquez, D. 2002. Los caminos de las semillas de papa en el altiplano peruano-boliviano. Cultivos y Saberes 10:1-2.