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POTATOES IN FOOD SYSTEMS
RESEARCH SERIES
Report No. 4

Traditional Potato Storage in Peru: Farmers' Knowledge and Practices

R. Rhoades, M. Benavides, J. Recharte,
E. Schmidt, and R. Booth

INTERNATIONAL POTATO CENTER (CIP)

1988

COVER

The cover is adapted from an intricately carved gourd, or *mate*, obtained in an Andean potato farming community. This work of an anonymous peasant artisan shows Andean people's understanding of the potato's agricultural calendar from the breaking of a field to storage and sale of the harvest.

The purpose of this interdisciplinary research series is to encourage debate and advancement of knowledge about production, distribution, and utilization of potatoes in food systems of developing countries. The views expressed are those of the author(s) and do not necessarily reflect the official position of the International Potato Center.

Comments are invited.

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Acknowledgements

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Robert E. Rhoades

TRADITIONAL POTATO STORAGE IN PERU: FARMERS' KNOWLEDGE AND PRACTICES

Abstract

This monograph analyzes farmer knowledge of traditional potato storage systems and technology within the context of a changing Peruvian agriculture. Due to a complex ecology and a blend of subsistence and commercial production, Peruvian storage patterns are among the most diverse in the world. The coast, with its commercialized production, and tropical desert climate supports a different storage pattern than is found in the highlands where conditions are cooler and agriculture more traditional. Market relations of the coast and highlands also vary and thereby affect storage practices. Stress in the report is placed on farmers existing practices but against the backdrop of pressure to change. The wealth of farmer knowledge about storage problems and solutions is seen as a starting point for improving traditional systems.

Compendio

Esta monografía analiza el conocimiento del agricultor sobre los sistemas tradicionales de almacenamiento de papa y la tecnología dentro del contexto de una agricultura peruana cambiante. Debido a la compleja ecología y una combinación de subsistencia y patrones comerciales de producción, los patrones peruanos de almacenamiento se encuentran entre los más diversos del mundo. La costa, con su sistema de producción comercializada, y clima tropical de desierto presenta un patrón diferente de almacenamiento que el que se encuentra en la sierra, donde las condiciones son más frías y la agricultura más tradicional. Las relaciones de mercado en la costa y sierra también varían y, por lo tanto, afectan la práctica de almacenamiento. Se enfatiza las prácticas existentes de los agricultores contra la presión de cambio. Se considera como un punto de partida para el mejoramiento de los sistemas tradicionales el conocimiento que tiene el agricultor sobre los problemas de almacenamiento y sus soluciones.

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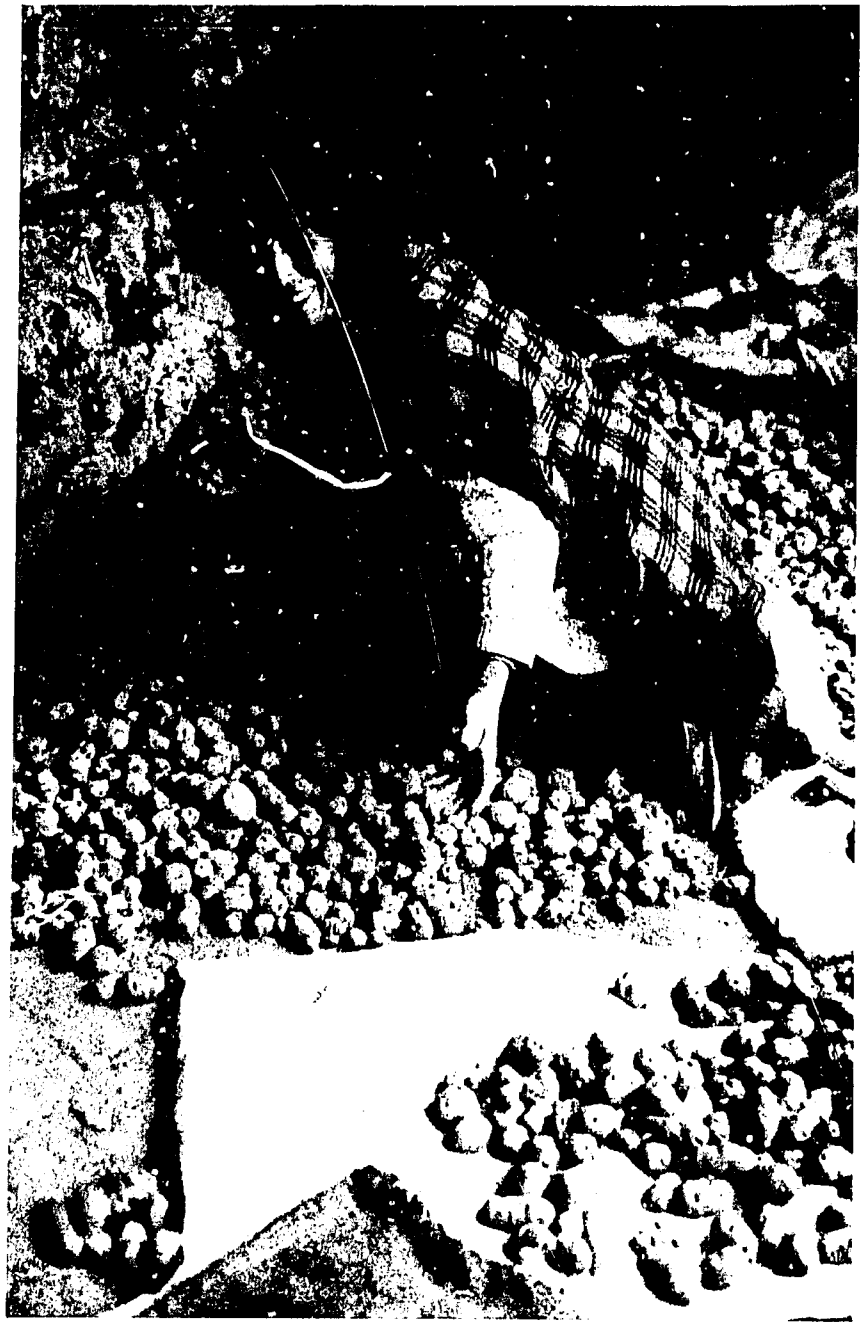


Photo 1. "A grid of storage facilities --local, district, regional and state-- may respond better than expensive but inaccessible silos to the differing requirements of diverse population groups. Every social unit, from a single household or village to a nation, needs some form of storage to meet immediate food requirements. A dry, pest-free cupboard can play just as effective a role in ensuring that food is accessible as a strategic national cereal warehouse."

Gerard Noonan, 1983

Photo by Gordon Prain.

I. Introduction

During the last decade, a growing number of agricultural development researchers and policy makers have recognized the importance of post-production activities in the food systems of developing countries (FAO, 1981; Maxwell, 1982). In addition to marketing, processing, handling and food preparation, storage has loomed as a major theme. In particular, reducing physiological and pathological losses of grains, roots, and tubers in the storage phase was seen as a way to increase food availability and security. Using the potato as an example, Booth and Burton (1983) calculated that a 50% reduction of post-harvest losses in potatoes in less developed countries would be equivalent to a 12.5% increase in potato yields. In addition, improvement in potato storage can have other benefits: help farmers meet optimum planting dates, more effectively link seasons and production zones, even out market supplies and price fluctuations, or reduce cost of seed, often the most expensive single item in the planting package (Rhoades, 1986).

Although farmers have been storing potatoes in a traditional manner for centuries, rarely have the problems or the knowledge acquired by farmers been studied or incorporated into post-harvest technology projects or seed potato programs. Both biological and social scientists have been guilty in neglecting existing post-harvest technologies and practices. In the few cases where an interdisciplinary approach involving farmers has been tried, successful design and transfer of new technologies and management practices have resulted (Werge, 1977; Rhoades and Booth, 1983).

1. Research Objectives

The objectives of this study are: (1) to analyze contemporary potato storage practices in the main producing regions of Peru; (2) to understand their function and position within the broader agricultural system.

Storage in the homeland of the potato should not be understood in isolation, as a purely technical phenomenon, but rather as a cultural practice which serves the needs and goals of rural households. In this regard, traditional storage is a manifestation of and in turn influences production, distribution, seed exchange, marketing, processing, and consumption.

By documenting the various forms of existing farm-level storage practices in Peru, we hope to provide social and biological scientists engaged in agricultural research and development with appropriate insights into why farmers do what they do in regard to storage practices. This information should be valuable for generating appropriate technical solutions for producers and more workable programs for policymakers and planners. The need for appropriate post-harvest solutions is particularly pressing in the Andean region where numerous past attempts by development agencies have resulted in large-scale storage "white elephants," unused and unappreciated by farmers.

2. Methodology

Anthropological research on potato storage at both the national and local levels was undertaken in the highlands and the coast in various stages between 1980 and 1984. Stages of the study were:

- A bibliographic review of studies dealing with potato storage in Peru, including information about production and processing relevant to storage patterns.

- Informal, focussed surveys of Cañete and Barranca on the coast and Mantaro Valley and Cusco in the highlands. Two regions were selected in each of these agroecological zones in order to assess the variety of situations under which potatoes are stored.

- In-depth ethnographic case studies of the community of Palca in Tarma Province, Junin, and several zones in the Department of Cusco.

The study areas were selected primarily on the basis of agroecological zone and type of farming system. Cañete represents a coastal valley with over 30 years of commercial production of potatoes, while Barranca located to the north of Lima has only become a commercial potato producing region in the past 10 years. In Cañete, small- and medium-sized potato farmers are important while in Barranca large cooperatives are predominant. In the high lands, the Mantaro Valley supports a largely market-oriented potato agriculture sector while Cusco is an example of traditional potato agriculture. A detailed ethnographic study of storage in Palca, on the eastern slopes of the central Andes, offers yet another storage system with its strong emphasis on commercial production for the Lima market and seed production for the highlands and coast.

Map. Location of Study Regions within Peru

The field survey technique employed at the farm and market levels was largely that of informal open-ended interview schedules. In Palca and Cusco, however, formal questionnaires were administered. The farm-level data for Cañete, Barranca, and the Mantaro Valley were based on individual farmer case studies (280 informal interviews). Questionnaires were answered by 92 farmers in Palca and 122 in the Cusco survey. Field observations were compared to official statistical information from each region, if available and relevant to the topic. Stores of individual farmers were visited in order to stimulate conversation first-hand. We have attempted to link macro-storage issues and patterns with farmer storage activities by shifting our focus from a national and regional perspective to include the local community and individual households.

Photo 2. A CIP anthropologist interviewing a farmer about her seed storage in Cusco.

3. Elements of Storage

Storage can be defined as that stage in the agricultural cycle aimed at preserving or holding crop or livestock produce through time until it is ready to be utilized, consumed, exchanged, or released onto the market. Storage strategies of households or communities involve technical, economical, and sociocultural activity. Storage is a technical phenomenon because the physical place has, ideally, characteristics of design, engineering, and management which aim to reduce losses, preserve seed, or promote security. Economical because a common function of storage is to "regulate the movement of the produce in time" (Shaw and Booth, 1980: 1), in accordance with market demand or the demands for consumption by the farming unit. Sociocultural because storage decisions are made by the household, and sometimes, by traders, communities, or nation states. Storage technology and management are integral parts of the on-going total life of human groups and must thus involve cultural aspects such as use of household space, architecture, exchange networks, and gender issues. Variables such as patterns of home consumption, family size, architecture of the house, and folk beliefs can help explain many characteristics of traditional storage.

Generally speaking, potato storage practices and tuber characteristics differ considerably according to whether the tuber is intended for seed or consumption. In this report, therefore, storage of seed potatoes and potatoes for home or market consumption will be treated separately, although we must keep in mind that farm households constantly attempt to keep their options open. Potatoes may be stored as seed but in such a way they can be later consumed or sold as ware potatoes and, conversely, potatoes stored as ware may be under certain conditions of seed scarcity used as seed. It is important to remember that storage is an integral link in the complete agricultural cycle and must always be understood against the broader background of production and consumption.

II. National Production and Consumption Characteristics

The potato is one of the most important food crops of Peru, ranking second only to maize in area planted. In 1979, the potato occupied 242,000 has (Estad. Agr. 79) and represented approximately 20% of the national agricultural lands under production for direct consumption (Flores, 1980:4). Although the potato had dropped to 199,000 has by 1981 and 172,000 by 1984, it still remains the second most important food crop (Ministerio de Agricultura, 1981; FAO, 1985). Yields at the national level are low (7.8 kg/ha) and production is mainly in the hands of small or medium farmers of the highlands. Seventy six percent of the agricultural units below 5 has plant potatoes and control 52% of the potato area, producing 46% of the total national harvest. Potato production is also important to medium-size agricultural enterprises: 23% of production units between 5 and 100 has cultivate potatoes. They plant 40% of the land with potatoes and produce 33% of the amount harvested. Agricultural units larger than 100 has are only 1% of the units planting potatoes but control 8% of the land surface and produce 21% of the potatoes harvested (Flores, 1980: 43).

1. Major Production Zones

The potato is adaptable to a wide range of climates. Peru's great ecological variability allows for complementary planting dates and, up to a certain point, a continuing although uneven supply to major markets. The potato is produced in several agroecological regions of the country: irrigated valleys on the coast, inter-andean valleys and high plateau of the sierra, and increasingly on the humid eastern slopes of the Andes (Table 1). Coastal potato production is capital-intensive, uses modern inputs and technology, renders high yields and is mainly destined for coastal urban markets. Production in the highlands, in comparison, is less capitalized, utilizes more traditional technology, and is geared more toward home consumption. Nevertheless, a modernized, commercial potato sector coexists along with traditional production, especially in the central highlands.

Table 1. Area and potato production by agroecological zones (%)

Agroecological zones	Area	Production
Coast	4.5	9.4
Highlands	94.8	90.0
irrigated	(15.6)	(19.7)
rainfed	(84.4)	(80.3)
Jungle	0.7	0.6
Total	100.0	100.0

Source: Flores, 1980: 32

In addition to the coastal-highland division, three latitudinal regions can be distinguished: (1) central, (2) northern and (3) southern (cf. Table 2). The central region is the most important production zone in volume and is the main supply region for Lima. In this highland zone, the most important Department is Junin (35% of arable highland area is planted in potatoes), especially the region of the Mantaro Valley. On the coast, the most important Department is Lima, which contains the valleys of Cañete and Barranca.

In land area planted, the southern region is almost as important as the central region although commercial production is less important and average yields are lower than in the central region. The Departments of Cusco and Puno have the highest percentage of total land area planted to potatoes in Peru (18% and 11% of the highland area respectively).

Potato production in the central highland and coastal zones where the highest yields are obtained is the most modernized in terms of technology. Improved varieties, fertilizer use, insecticides, and access to credit and agricultural extension are much more developed than in the southern region. The Mantaro Valley, for example, in 1971 had approximately 32,311 has planted to improved varieties which represented 63% of the total hectareage. The departments of Cusco and Apurimac together, on the other hand, had only 6,256 has under improved varieties, representing approximately 18% of the total.

Table 2. Potato production by latitudinal and agroecological regions

	Northern highland/coast		Central highland/coast		Southern highland/coast		Total highland/coast	
000 has	52.6	0.3	98.2	7.9	81.0	1.2	231.8	9.4
(%)	22.7	3.2	42.6	84.0	34.9	12.8	100.0	100.

Source: Cited in Scott (1981:356).

2. Marketing

Nationally, the network of market flows of the potato is still incompletely understood (cf. Scott, 1985). The region which consistently experiences the highest production shortages is the central region where Lima is located. Regional and inter-regional flows exist; the latter are probably the more important in terms of volume even though conditions of transport are not ideal.

In the highlands, small producers sell potatoes mainly in local markets and generally in small quantities, while commercial producers frequently transport and negotiate the sale of their own production or sell it to middlemen (intermediarios). On the coast, sale at local markets (feria) is infrequent. The most widespread practice is the sale "in the

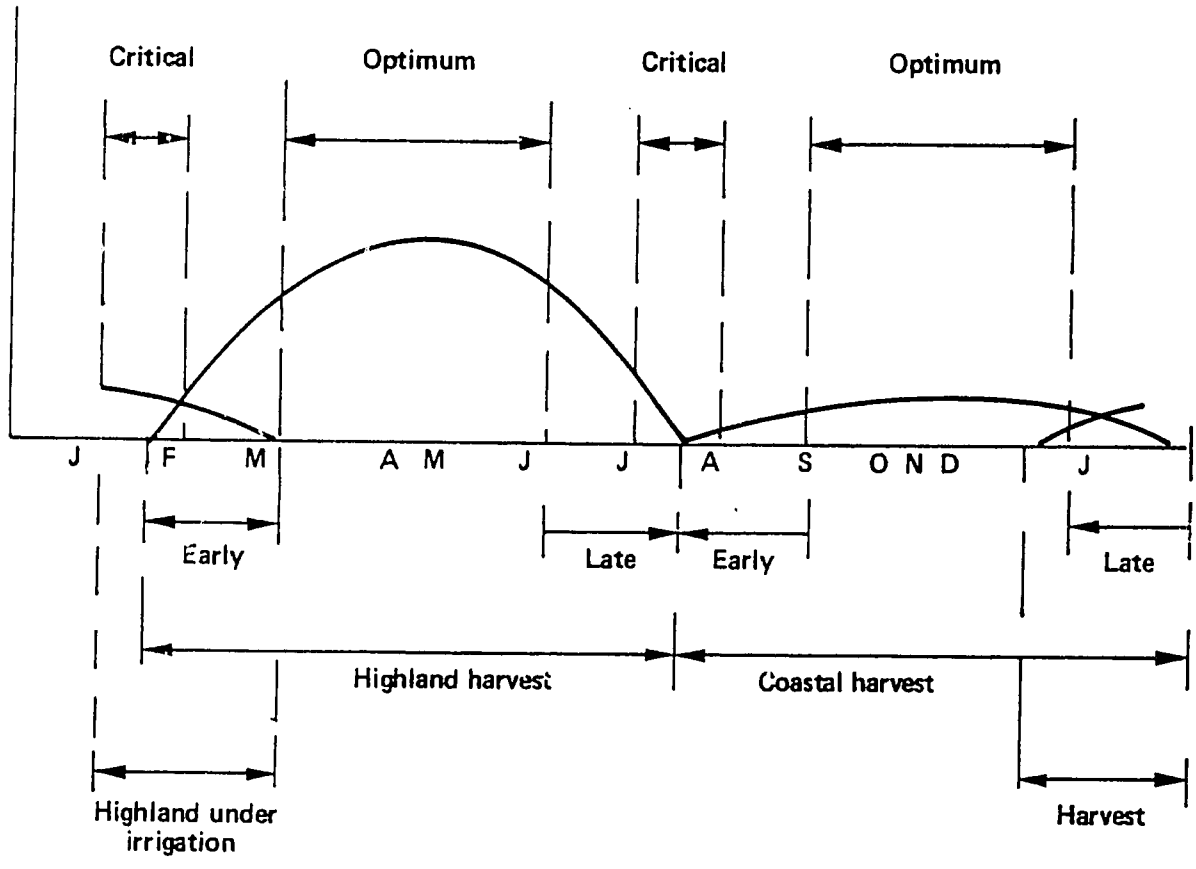
field" of the upcoming harvest to trader-truckers (a detailed description of the potato marketing system in the Mantaro Valley and Cañete can be found in Scott, 1985).

3. Supply

The combination of coastal and highland production usually covers the potato demand of Lima throughout the year. Occasionally, however, toward the end of the harvest season on the coast and in the highlands, "critical" periods of supply arise which cause strong price increases. By the same token, periods of oversupply which have the opposite effect also occur.

Figure 1 illustrates the characteristics of supply. The supply of potatoes is, in part, controlled by the production calendar which is diversified according to the various agroecological zones: irrigated high land production, non-irrigated highland production (interandean valleys, eastern valleys), and the coastal production.

Figure 1. Cyclical fluctuation in supply of potato



Source: Fernández, Angel 1976:5

4. Role of Storage in Potato Marketing and Supply

Two kinds of storage structure can be distinguished in Peru: (1) small- to medium-scale rustic stores of various types used and owned by independent producers or cooperatives; (2) large-scale stores with a complex infrastructure managed mainly by public enterprises.

Most potato farmers utilize several storage systems simultaneously, each with its own purpose and physical design. Presently, the most important role of storage in the control of supply corresponds to the first type of storage structure and strategy, which is largely in the hands of small- and medium-scale producers of the high lands where favorable temperatures and an ancient storage tradition prevails. Household level storage as an important target of agricultural development research, however, has been largely overlooked.

Practically every household in the highlands stores part of the potato harvest for home consumption, seed, and periodic sale. Storage on a small-scale on the coast, however, is a marginal practice owing to the problems posed mainly by ecology and market conditions. Household storage on the coast, if it occurs, is almost exclusively for seed tubers.

The second storage type dates back to the 1960s. These were developed by the Peruvian government with the intention to regulate the supply and price of the potato in the main urban centers of consumption. In the highlands, forced- air stores were built in (1) Quiulla (La Oroya) with a 7,000 tons capacity, (2) Juliaca (Puno) with a 3,000 tons capacity, and (3) Anta (Cusco) with 5,000 tons capacity, and (4) Otuzco (La Libertad) with 1,000 tons capacity. Others exist also in San Mateo, Chiclayo and Huancayo (see Manzaneda, 1984 for a complete listing of large stores in Peru).

Photo 3. The 7,000 ton stores at Quiulla (La Oroya) which have been rarely used by farmers. (R. Rhoades).

These stores have never served their purpose. The store at Quiulla, for example, which was designed to regulate supplies to Lima, is used presently to store rice, milk powder, and other products. Various reasons can explain this situation: bureaucratic problems, difficulties in collection, high cost of storage, and sociocultural reasons.

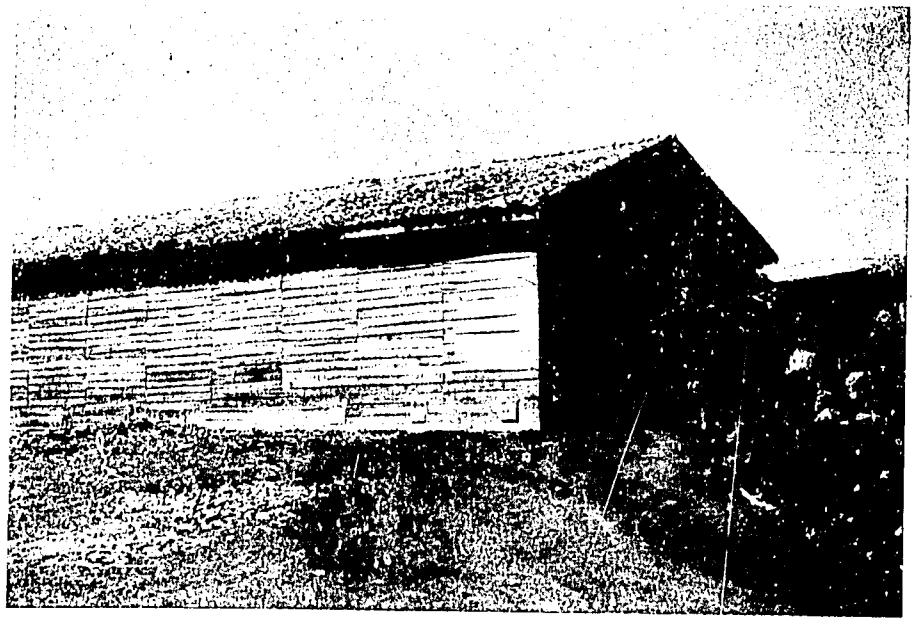


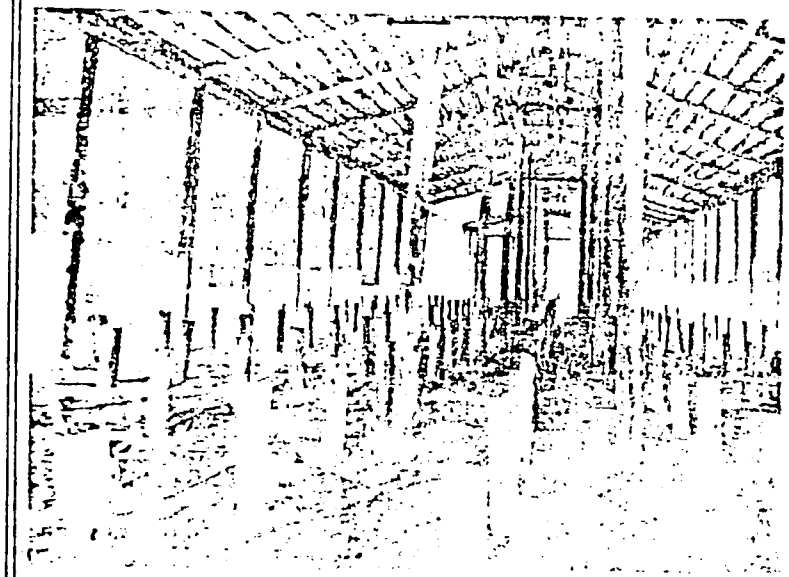
Photo 4. A government store at Ticlio which was never used by farmers and was later abandoned. (R. Rhoades).

5. Consumption

The main purpose of potato production on a national level is for consumption; 65 to 70% of the national production goes toward this end, 20 to 25% is used as seed potatoes, and 10% is fed to animals or is lost (Flores, 1980:66). An insignificant proportion (2%) of the potato harvest is destined for industrial use.

On the national level, 41% of potato production is utilized by farmers for home consumption, 29% for regional interchange, and 30% for the market (Flores, 1980: 59). On the average, in the highland region, the percentage destined for home consumption is greater than that destined for market, while on the coast, precisely the opposite occurs. This fact is linked to different consumption patterns between coast and highlands.

Around each major consumption center is a regional potato producing area. In the case of Lima, for example, during 1968-75, 51.4% of the potatoes consumed had their origin on the central coast (mainly Cañete and Barranca) and 42% in the central sierra. Only 6.2% of the potatoes consumed in Lima come from the northern highlands and 0.4% from the southern highlands (Girón, 1976: 9.6.5).



Tal como se puede apreciar el "frigorífico natural" más alto del mundo ha sido desmantelado. Se encuentra inservible a pesar de que nunca se ha utilizado para almacenar papa. (Foto: Mario Torreblanca)

Frigorífico natural de Ticlio es ahora un inservible galpón

TICLIO 26.- (Por Javier Ascue Sarmiento, enviado especial).- El frigorífico-depósito "al natural" construido hace tres años en Ticlio, a cinco mil metros sobre el nivel del mar, para almacenar miles de toneladas de papa, ha sido completamente desmantelado. Actualmente se encuentra convertido en un inservible galpón.

Gran parte de sus instalaciones fueron saqueadas por desconocidos aprovechando que el importante almacén había quedado abandonado por motivos que se ignoran. Este -como informó nuestro diario hace unos años- fue construido para depositar los excedentes de las campañas de papa para, desde allí, abastecer durante todo el año los mercados capitalinos.

El Ministerio de Agricultura invirtió una considerable cantidad de dinero para ejecutar la obra. Sin embargo, nunca se llegó a utilizar. Ni un kilo de tubérculo se ha depositado siquiera para tener pleno conocimiento de su funcionalidad. El saqueo de valiosos tablones, especialmente preparados para conservar la temperatura, se ha producido sistemáticamente desde el momento en que fue retirado el guardián.

Miles de pasajeros y choferes que transitan diariamente por la carretera central observan con sorpresa el lamentable estado en que se encuentra el gigantesco pabellón-frigorífico "al natural". Gran parte del techo también ha desaparecido.

Este depósito, el primero de cuatro proyectados, fue construido como parte de un plan piloto en la parte más alta de Ticlio. El ambiente ha sido escogido por sus especiales características de funcionalidad en cuanto a refrigeración se trata. La temperatura en el lugar oscila entre 12 y 25 centígrados bajo cero.

El gigantesco almacén contaba con alcantarillas "a ras del suelo" para regular el ingreso del aire helado de la atmósfera al interior del depósito así como con otros sistemas que permitían conservar la temperatura necesaria al igual que un frigorífico eléctrico. Todo este sistema también ha desaparecido.

El Comercio

A 12 • NACIONAL

Expertos comprobaron que el almacén natural de Ticlio está totalmente destruido (

Nadie usa almacenes especiales para la papa

LIMA, SABADO 12 DE SETIEMBRE DE 1981..

Al natural y barato

Figure 2. News stories about the failed large-scale potato stores in the highlands. El Comercio, 27 de abril, 1984

Lima is the country's main center of consumption, absorbing an average of 12% of the national production for the years 1971-77, or 221,457 tons yearly (Flores, 1980:71). Other important centers of consumption are the cities of Huancayo, Cusco, Puno, Chiclayo, and Arequipa.

In highland areas, per capita potato consumption in 1971-72 was reported at 130 kg (Scott, 1985:32). In the Mantaro Valley, for example, 70% of production is sold on the market (including potatoes destined for regional interchange) and 30% is used for consumption and seed (Flores, 1980:60). The percentage destined for home consumption is even higher among the rural population of the southern highlands.

III. Storage on the Coast

The coastal area cultivated in potatoes expanded rapidly during the 1950s and 60s reaching 10% of the national potato hectareage. In 1982-83, however, high production costs and unfavorable price conditions brought a drastic reduction in area. The production period is mainly between April, when the first plantings are undertaken, and December when the last harvests take place. The most important harvest months are September, October, and November. The limiting growing factor on the coast is the high temperatures which occur between November and March. Few potatoes are produced on the northern coast due to higher temperatures throughout the entire year and a smaller market demand. On the central coast relatively cool weather between May to September and the large urban Lima market have made potato production feasible and normally profitable.

1. Cañete and Barranca

The bulk of coastal production is found in the central region, especially in the valleys of Cañete, Barranca, and Ica. The former two were selected for this study in order to show their storage characteristics for the following reasons:

- important in the supply of potatoes to Lima;
- located at approximately equal distances from Lima;
- present significant production differences (planting times, types of production units, planting traditions), and
- experiments and demonstrations with improved seed storage have been undertaken by CIP and the national potato program in both valleys.

The Cañete Valley is located to the south of Lima (149 kms) by the Cañete river. Barranca is found to the north (180 kms) and consists of the agricultural region irrigated by the rivers Supe, Pativilca, and Fortaleza.

In both valleys, the potato represents one of the most important crops in terms of area planted. In Cañete, in 1981 the potato was the third crop (13.2% of the area) following cotton and maize while in 1985 it had dropped to fifth. In Barranca, during 1981, the most important crop is sugar cane, followed by corn, cotton, beans, and potatoes in fifth place (8.1% of area planted).

Potatoes are produced in Cañete by small- and medium-size producers and by cooperatives (now primarily parceleros of the CAPs). In 1979, 40% of the land planted to potato corresponded to cooperatives, 42% to medium-size producers with over 5 has in potatoes, and 18% to "small" producers

with under 5 has in potatoes (cf. Scott, 1981:72).[1] The area planted in potatoes by the cooperatives was diminishing before the parcelation period. In 1980, only 25% of the potatoes were produced by cooperatives. The importance of small the by cooperatives. The importance of small potato producers can be better understood if we consider that 84.2% of all holdings in the valley were below 3 has before parcelation (Rhoades and Benavides, 1980).

Table 3. Potato production valleys on the central coast

Valleys	Area planted (has.) 1980	1985
Cañete	3,000	629
Barranca	1,700	534
Ica	1,050	627
Huacho	700	402
Chincha	700	109
Huaral	650	297
Puente Piedra	600	169
Rimac	250	198
Lurin	150	96
Nazca-Palpa	150	363
Total	8,950	3,424

Source: Min. de Agricultura. Dirección Regional II, Lima: 1980.
Min. de Agricultura y Proyecto PADI, 1986.

In Barranca, the importance of small-scale agriculture was considerably less than in Cañete. Thus, 70% of the area planted to potatoes in 1981 was cooperative land. The small-farming operations were mainly restricted to the sector called Caraqueño.

In Barranca, like Cañete, only improved varieties are planted: Ticahuasi, Revolución, Mariva and Tomasa Condemayta. In Cañete, only 1% is kept for home consumption, the rest being sold (Flores, 1980). Due to proximity, approximately 80% of Cañete's potato production is sold in

1 Beginning in 1983, the cooperatives on the coast began to parcel their land among the members. By 1986, all cooperatives had to a greater or lesser extent undergone parcelation. How this will affect cropping and storage patterns of the valley has not yet been studied. This report deals mainly with the pre-parcelation period.

Lima, the remainder going to the markets of the south (Arequipa, Ica, Tacna, Puno, and even Bolivia). In 1978, Cañete farmers exported 2,000 tons to Bolivia during October and November. The situation of Barranca was similar: 70% of the potato production went to Lima, 25% to the north, and the remaining 5% to the Huaraz region (Production Agency of Barranca, personal communication).

Coastal producers obtain seed tubers from certified and other high land seed growers, especially from the valleys of Mantaro and Tarma. Only a small portion of the land planted in potato is sown with seed produced on the coast (21% in Cañete, cf. Monares, 1979), in many cases using the farmer's own stock. This seed, known as criolla, is of poor phytosanitary quality but represents various advantages for the producer:

- lower cost;
- possibility of early planting in order to harvest during the months of high prices (while the criolla can be planted in March, the "highland seed" (serrana) does not arrive at the coast until April or May), and
- reduction of approximately three weeks in the growth cycle.

Main limiting factors, however, for the use of criolla seed are:

- lower yield compared to the highland seed, and
- storage difficulties owing to technological and economic problems.

2. Seed Tuber Storage

Storage of seed potatoes is more important on the coast than storage of consumer potatoes, leaving aside low production years such as 1985 when few potatoes were stored. Strategies for preserving seed for the coastal planting are: (1) refrigerated storage, (2) colca or house storage on large or small-scales, and (3) storage of criolla seed at higher elevation.

a. Cold storage. In 1963, a 3,000 ton (approximately 10% of total regional production) cold storage facility was constructed in the Cañete Valley by large land holders (hacendados) to store primarily seed potatoes. However, in 1980 this storage facility was being used at only two-thirds its total capacity. Out of 2,000 tons stored, seed potatoes represented only a small percentage. The store was nonetheless of great importance as nearly all farmers who planted criolla seed purchased from producers storing in the cold store. Storage in refrigerated stores is not a rational option for small farmers and many cooperatives or medium sized producers who depend on agricultural credit.

A typical farmer using the refrigerated store keeps enough potatoes to justify cost of packing, leasing a truck, and hauling. Small farmers needing 500 to 1,000 kg/year of criolla seed find it difficult not only to obtain a space for such a small quantity, but also to invest their time, labor and money in transporting potatoes to the store. A more rational way, given these conditions, is to store in the traditional colca or simply purchase seed. Colca (a Quechua word meaning storage) is the folk terminology used by farmers to refer to storage inside the house, generally under rustic conditions.

b. Seed storage in traditional store (colca): Small-scale. Storage on small-scale (less than 10 tons), compared to large-scale storage (more than 10 tons), is more rustic and used mainly by small farmers. In the case of Cañete, small-scale storage occurs with higher frequency than in Barranca, probably due to the longer tradition of potato cultivation in Cañete.

Storage time is approximately four months (December to March) from the last harvest (not later than December) of seed plots to the planting of criolla seed at the beginning of the growing season. Farmers attempt to reduce storage time to the possible minimum. Some farmers produced and stored criolla seed for their own use, while others sold part of it.

The percentage of coastal farmers that use colca storage is not clear, although the majority have tried it at least once. In some cases, farmers achieved relative success and used colca regularly to store criolla seed, at least up to 1984 when the coastal hectareage in potatoes dropped drastically. Farmers who typically use the colca system are small producers for whom the cheapness of criolla seed is more important. However, the majority have been disappointed with it due to problems with insects, rotting, dehydration, and low germination rate. The only alternative could be to purchase seed tubers from those who use cold storage.

Farmers who practice colca storage always begin by experimenting with small quantities of seed which is later increased as they "perfect" their system. Each farmer has his own private recipe for good storage. Farmers utilize traditional experience and knowledge to design their own solutions: putting sand on the floor to "refresh" seed tubers in one case, preferring to concrete the floor in another, or planting bananas close to a store "because they attract the wind." Efficiency of storage varies from case to case, depending on the conditions of light and ventilation. Commonly, tubers with signs of insect infestation, rotting, and dehydration are seen. Seed potatoes stored on the coast are not produced by specialized seed producers, and are generally of low quality although some farmers are serious about pre-storage selection. Stored seed tubers typically come from the last harvest (almost always presenting the worst sanitary conditions). Seed, however, is usually desinfected before storing.

Figure 3. Small-scale coastal colca

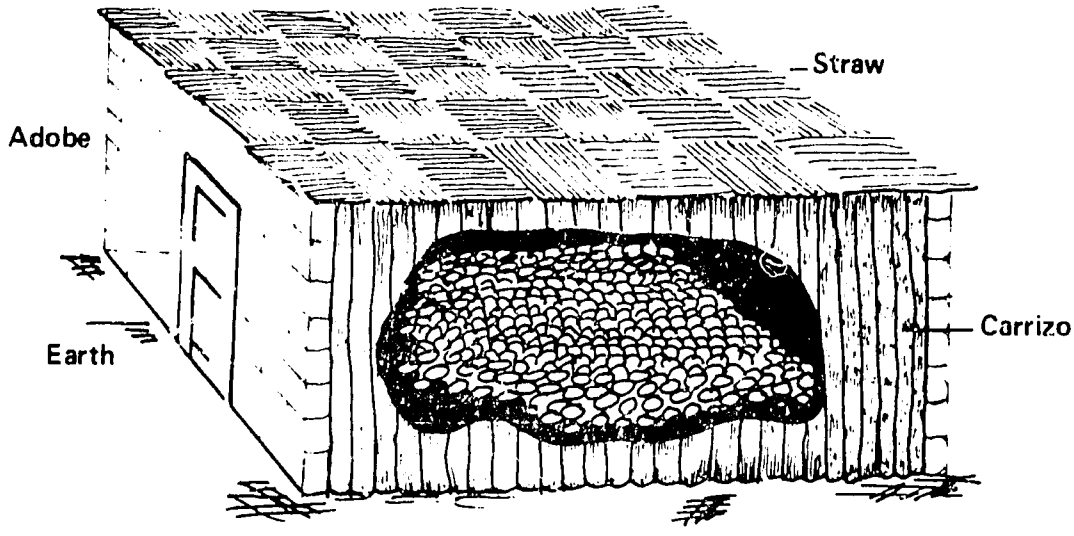


Figure 4. Small-scale coastal colca

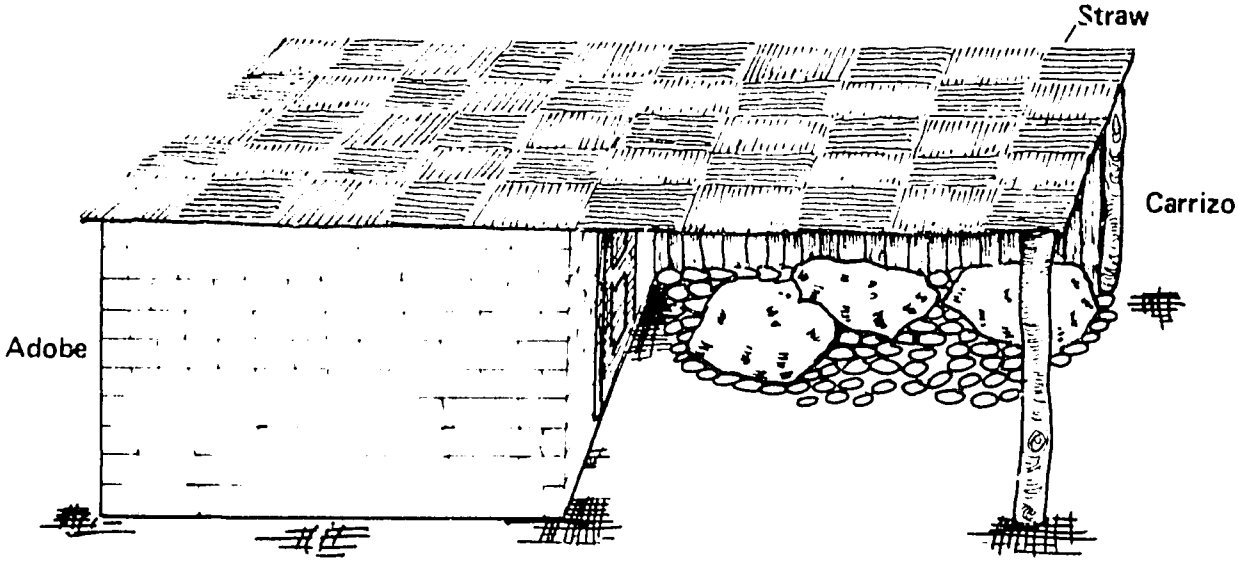


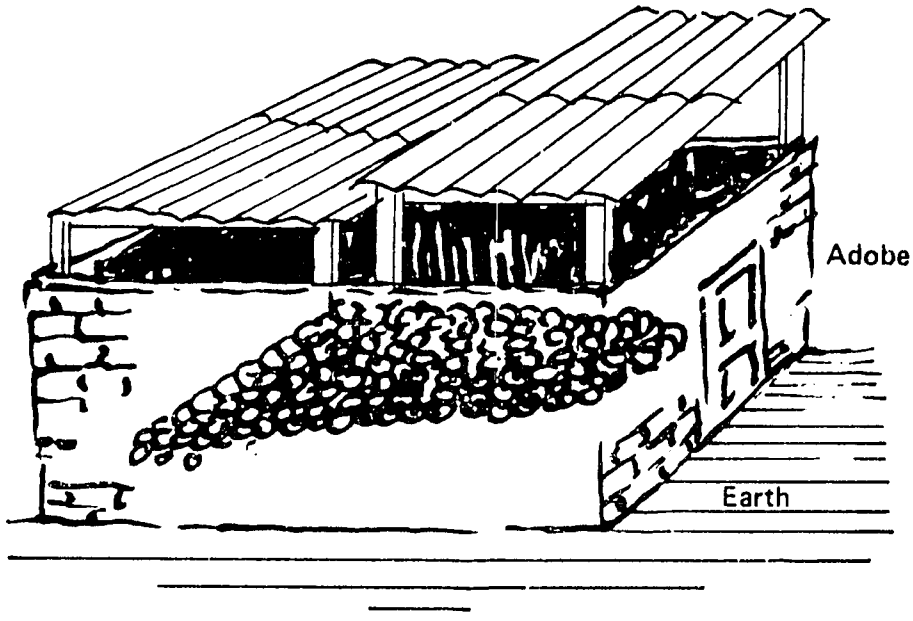
Photo 5. Small-scale storage (colca) in Cañete. (J. Recharte).

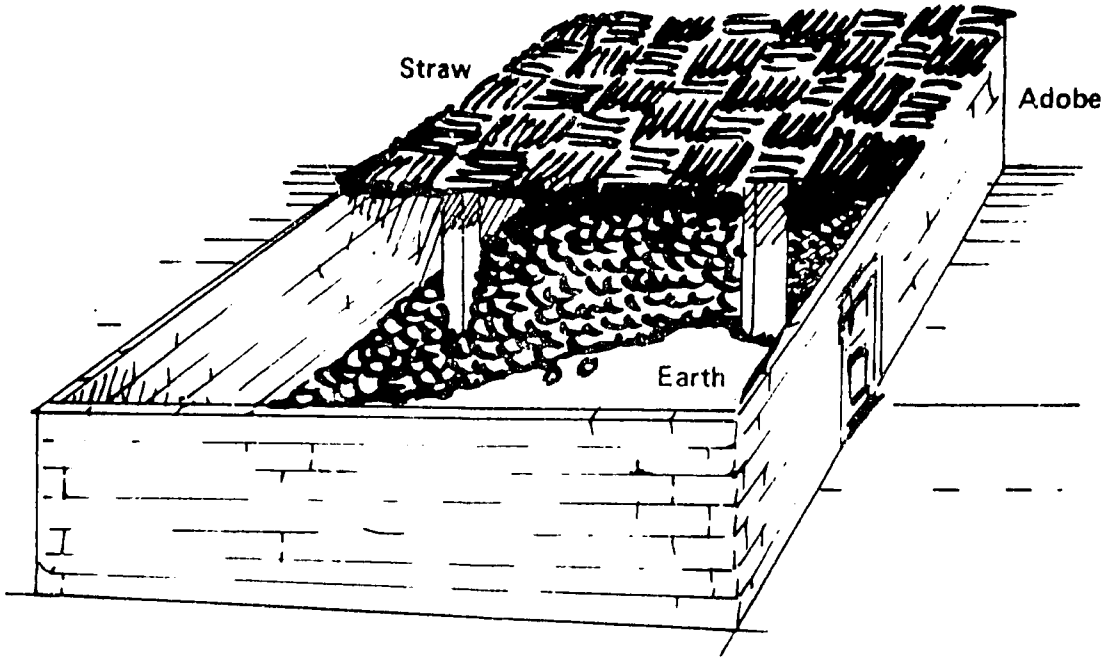
c. Large-scale seed storage: Large-scale storage in colca (30 to 50 tons of seed each year) is practiced only by members of the Peruvian born Japanese colony of Cañete. The Japanese colony is not representative of the larger body of farmers and is characterized by: (1) medium producers (over 5 has), (2) full-time farmers, (3) specialized in seed potatoes and some rotation crops like sweet potato, corn, or marigold, and (4) known by all farmers of the valley for their farming expertise.

Seed tubers stored by the Japanese farmers come from fields planted with highland seed. Seed potato production follows as much as possible, given the coastal climatic conditions, the requirements of a certified seed plot. Prior to storage seed tubers are rigorously selected by Japanese farmers, one of the reasons for their success in storage. Seed production fields are the last to be planted during June and the last of the season to be harvested in November. This seed is then planted in March signifying a 4-month storage period from December to March, the warmest months of the year.

Storage is under roofs, utilizing indirect light and ventilation. The floor consists of concrete or soil. Usually the floor and the walls are desinfected with the agrochemical "BHC" before storing potatoes. While potatoes are in storage, selection (recojos) is practiced once a month to discard bad tubers. Piled potatoes (ruma) reach up to 50 cms depth, causing excessive growth of sprouts (guias) and therefore the need for desprouting.

Figure 5. Large-scale colca in Cañete





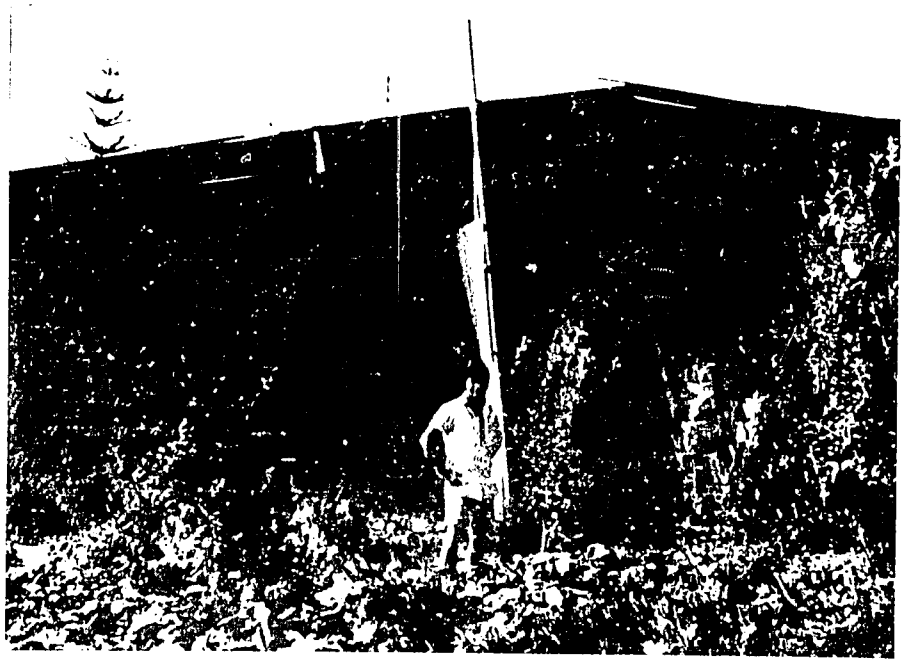


Photo 6. Large-scale farm storage (colca) in Cañete.

Photo 7. Large-scale farm storage (colca) in Cañete. Selecting seed.

This large-scale colca system is not homogeneously developed among all farmers. At one extreme are found especially constructed stores of bricks, corrugated metal roofing, and concrete floors with special ventilation features. At the other extreme, a Japanese-Peruvian farmer keeps his seed in his shed for agricultural tools and machinery, on a dirt floor and does not discard the bad tubers.

What Japanese-Peruvian farmers have in common is a relatively efficient coastal storage system which offers, in their view, security. These farmers indicated that the yields attained with coastal seed were similar to those obtained with highland seed, even though it meant higher seed density and higher quantities of fertilizers than required for high land seed.

d. Large-scale seed storage: Barranca. Large-scale rustic stores (30 or more tons) in Barranca, where no Japanese colony is found, differ from those found in Cañete. Rusticity is the main feature. Refrigerated stores do not exist in Barranca, stimulating producers to keep seed potatoes in houses, stores of various kinds, or other available places. The only producers that store regular amounts of seed in Barranca are cooperatives.

In Barranca, unlike Cañete, the last harvest occurs as late as February, thereby reducing the storage period to only two months. Nevertheless, storage in Barranca appears less efficient than in Cañete where farmers have at least 20 years of experience. The purpose, however, of storing criolla seed in Barranca is the same as in Cañete; that is, to help cut costs of production through utilization of less expensive, local seed.

The International Potato Center and the National Potato Program cooperated in 1981 to build a 100 ton capacity diffused light store that had reduced its dependence on highland seed by 50%. Interviews with cooperative managers revealed the following advantages of diffused light storage:

- Earlier planting and earlier harvest to avoid mosca minadora, the major pest on the coast which caused severe damage later in the season;
- higher price through harvesting before the main harvest period;
- lower costs of production since earlier planting gives rise to earlier emergence thus minimizing both pest and disease damage and reducing expenditures for pesticides and fungicides;
- flexibility in that the cooperative can plant as it wishes rather than being dependent on time of arrival of highland seed;
- criolla (local) seed stored in diffused light gave uniform, early emergence;
- seed tubers were 20% cheaper than "imported" highland seed. This, together with higher market prices, made the whole operation more profitable;

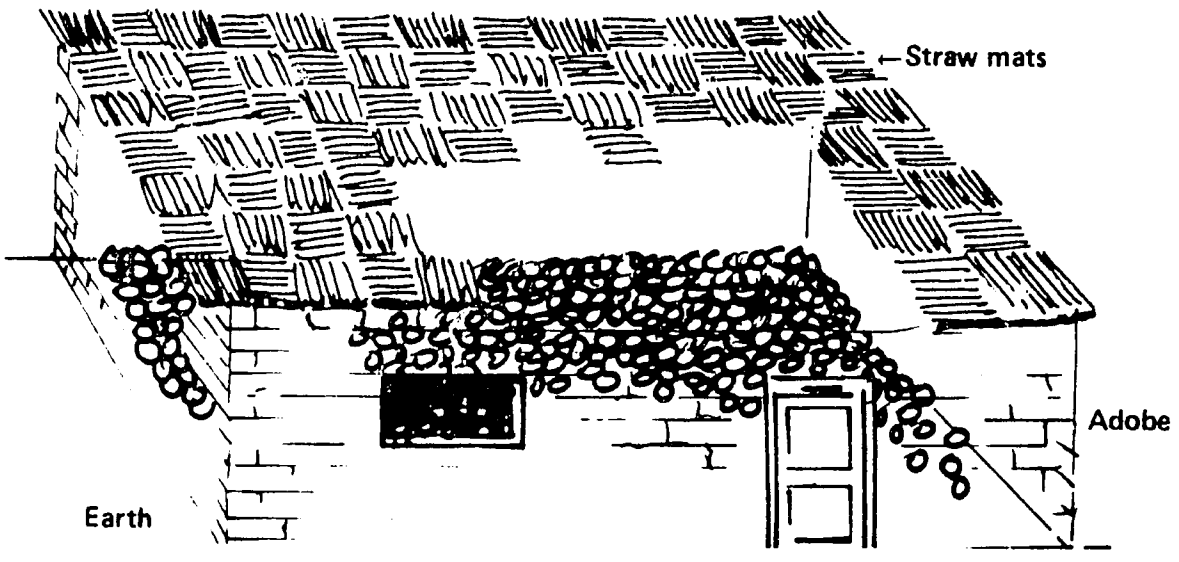
- reduction of credit costs which are incurred when they have to buy seed from the highlands.

Four cooperative storage types and strategies in Barranca were identified in addition to the diffused light store:

- Closed stores/sheds. Normally agricultural machinery, fertilizers, and other inputs are kept in these structures. The floor may be soil or cement. They are under roof and have poor ventilation. Generally, light enters the interior. The potatoes are placed on the floor and some insecticide is applied, especially against tuber moth.

  In some cases, seed potatoes are turned over periodically and bad tubers discarded. Generally, storage conditions are poor but since storage periods are short tubers maintain an acceptable condition. Cooperatives perceive storage as a serious technological problem, a fact underscored by their sending a portion of their criolla seed to high zones of the sierra above 4,000 meters (cf. paragraph 4 below for a description of this system).

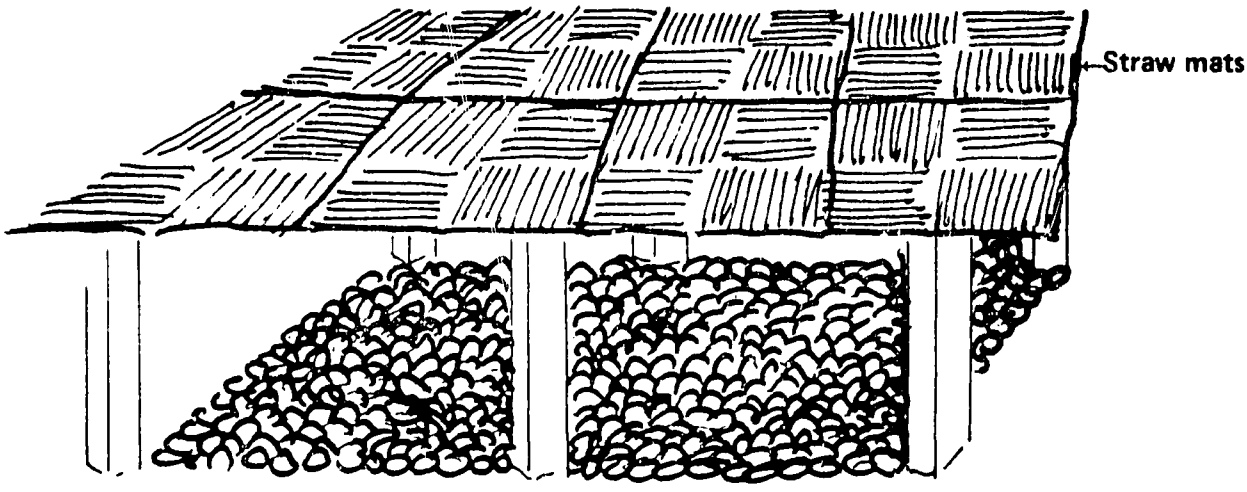
Figure 6. Barranca colca: large-scale enclosed store



- Ventilated room. This type of storage occurs in old houses with wood or concrete floor which have good conditions for favorable temperatures and ventilation. Some farmers open doors and windows at certain hours of the day to facilitate ventilation. These "stores" also have in direct light, but potatoes are piled in layers of 30 to 50 cms depth thus minimizing the amount of diffused light reaching the bulk of tubers. A better selection of tubers is practiced in these types of stores than in the shed-type.

- The tinglado system, which could be translated as "covered," has no walls (Figure 7). Success of tinglados vary greatly. Out of three visited, two contained tubers in very bad condition; insect attack and rotting was frequent. The third, however, located at the Cooperative Simon Bolivar preserved tubers well. It was intentionally built close to the beach where a cool breeze always blows, even in summer.

Figure 7. Barranca colca: large-scale tinglados



- Potato seed storage in the highlands. The cooperatives of Barranca combine rustic storage on the coast with removal of seed to higher elevations of the valley where climatic conditions are favorable for storage. It is still considered a risk to store potatoes on a large scale in Barranca. Highland places mentioned were Conococha (4,000 m.a.s.l.), Cajatambo, Raqui, and Qatac where lower temperatures prevail. Producers or businesses (seed handlers) deposit seed in sacks in vacant houses rented for storage.

Highland storage is seen positively by Barranca producers, as much for its good results as for its low cost transport and minimum rent of the stores. The cooperative Decisión Campesina has even constructed a special store of stone at higher elevations for criolla seed. Another cooperative stored 8 tons of Revolución seed (a variety with good storage qualities) from September to March in a dark room in Conococha, rented from a member of that community. At the end of the storage period, the potatoes had lost 1 ton in weight due to shrinkage. The seed is brought back to the coast several weeks before planting for desprouting and desinfecting.

3. Consumer Potato Storage

a. Future sale. Coastal potato production begins when the highland supply to the Lima market is diminishing, thus capturing higher prices in the early harvest period. However, when the harvest on the coast peaks, farmers face much lower prices for their produce. Farmers thus try to sell as much of their harvest as early as possible to take advantage of market conditions. Potato producers opt for a series of strategies which are often not recognized as storage. The harvest can be delayed for two weeks, and sometimes longer, at the risk that the produce will spoil. This was the strategy used most widely during 1981 when prices dropped dramatically during harvest. Once the harvest is accomplished, the tubers are kept in sacks in some cool place for several weeks. We located one producer who kept his potatoes in good condition for three months covering them with banana leaves. The main reasons, however, why farmers rarely store consumer potatoes are:

- Climatic constraints. Coastal temperatures make storage of ware potatoes over long periods impossible due to rotting and insect attack. Many farmers interviewed mentioned that potatoes stored in colcas turned green and became bitter rendering them unfit for human consumption.

- Uncertainty of price structure. All Cañete and Barranca farmers know that normally the best prices are obtained in July-August and December-January. Sometimes, however, potatoes stored in the highlands or produced in other regions reach the Lima market during these periods making prices fall sharply. In 1981, for example, overproduction occured in the Cañete Valley (3,200 has were planted with potatoes). Low prices did not cover production costs thus obliging farmers to store potatoes to await for better prices.

- Credit and cash needs. Many farmers work with credit from the Agrarian Bank and must pay their debts at harvest. Others need the flexibility to invest in subsequent crops at the end of the potato harvest.

- Inaccessability. Although rarely used by farmers, cold stores are found in Cañete and Lima. In 1981, despite low potato prices during October and November, no potatoes were stored in the cold stores of Lima (e.g. Santa Rosa, Aveco). In an interview with an administrator of these cold stores, which have a capacity of 1,200 tons of potatoes, we were told that some producers had stored seed potatoes but no table potatoes. Another reason for not storing table potatoes in Lima is the cost of storage space and the cost of transport from Cañete and Barranca.

- Legislation concerning monopolizing and speculation. Another factor which has limited storage of consumption potatoes at various times was the federal law 21411 which forbids adulteration, monopolizing, and speculation for profit with agricultural produce. This law dating to February of 1976, but modified in 1980 and anulled in June of 1981 forbade any hoarding or large-scale storing of food products. Farmers fear the government can impose this law at any moment and confiscate their potatoes.

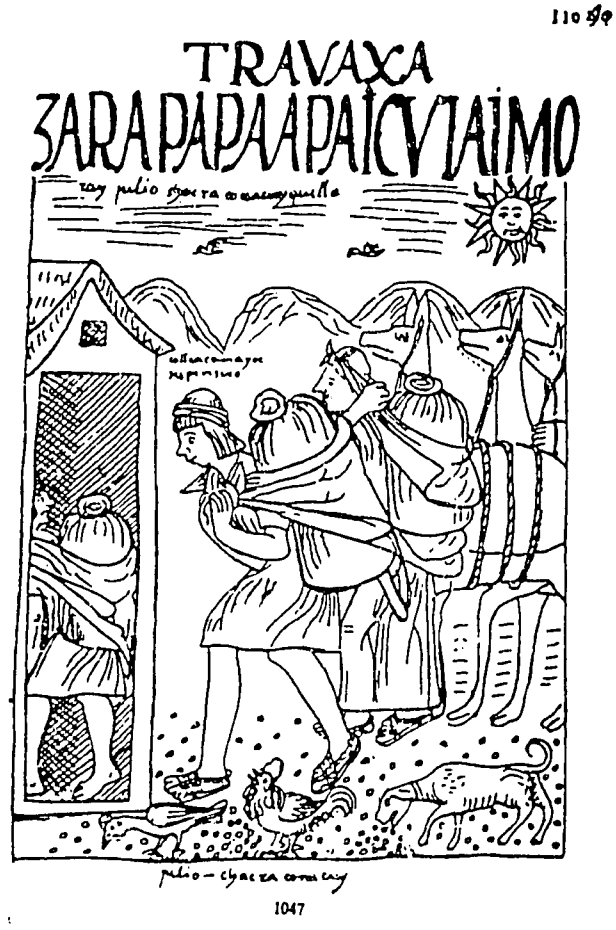
b. **Home consumption**. Coastal potato consumption becomes significant mainly at harvest time when fields are often gleaned after the main harvest. One strategy among coastal farmers is to plant ware potato fields at staggered dates thus allowing several harvests. Independent producers, especially small farmers, keep ware potatoes in closed paper sacks which help keep potatoes free of insects for several months. The quantity stored fluctuates between 200 and 400 kilos and serves for family consumption for 3 to 4 months. Toward the end of the storage period, potatoes shrink but are still edible. Another form of coastal potato storage consists of depositing potatoes in piles on concrete floors and covering them with banana leaves. Another involves burying potatoes in very dry sand. "When there is no work," one informant told us, "we live from potatoes stored at harvest time. Then we eat only potatoes as if they were bread or noodles." The quantity stored varied since workers received part of their pay in potatoes, or as a gift during harvest time.

IV. Storage in the Central Highlands

Potato storage in the Peruvian highlands is a tradition which reaches back to the earliest years of plant domestication by Andean populations. The storage strategy has for centuries been crucial in helping satisfy consumption needs of families and communities as well as linking production cycles through the maintenance of seed stock. Existence of a large, well-organized state storage network of pre-Inca origin as well as stores for individual households has been confirmed through archaeological research (Antúnez de Mayolo, 1981; Ravines, 1978; D'Altroy, and Hastorf, 1984; D'Altroy and Earles, 1985). Ravines (1978) has even argued that the capacity to store and preserve was an important element in the evolution of Andean civilization.

> One characteristic of Andean pre-hispanic culture has always been to maintain and accumulate its production for as much time as possible. The means of conservation used until today by the indigenous population are of very old origin and were practiced undoubtedly already at times prior to the Inca period.

Figure 8. A description of highland storage from the chronicles



Poma de Ayala, Felipe Guaman. El Primer Nueva Crónica y Buen Gobierno. (1613). Ed. Crítica de J.V. Murra y R. Adorno. 1980.

In the central highlands, the bulk of potato production occurs in the high mountain valley floors and adjacent slopes, especially in the altitudinal range of 3,200 to 3,800 m. The maximum height limit for potatoes is approximately 4,100 m where mainly bitter species and varieties are planted. The lower production limit is approximately around 1,000 m on the eastern slopes, where hot, humid conditions tend to constrain tuber formation. The lower limit in the western valleys lies approximately around 2,000 m, due to high temperatures and low rainfall.

The production cycle is adapted to the rainfall pattern, on the one hand, and to the frost patterns on the other. The main rains begin around October-November and the first frosts in May. Thus large-scale planting begins in October (campaña grande) and farmers try not to have fields with potatoes in the growth cycle when the first frosts begin. Nevertheless, planting can be done as early as May on irrigated land below 3,000 m and on land which is protected against frost in higher lying regions. On non-irrigated land, planting can be undertaken between July and August in the eastern valleys which have earlier rains and where the risk of frost damage is less.

A smaller percentage of planting occurs outside the optimal climatic period, with farmers attempting to compensate for the risk of losses through some economic advantage (e.g. better prices, lower cost of inputs, shorter vegetative cycle).

According to Graber (1974:12), six important potato production centers exist in the central highlands which contained the following extensions in 1974 and 1984.

Table 4. Main potato producing zones in the central highlands, 1974-84

	Area planted (has)	
	1974	1984
Mantaro Valley	14,200	16,959
Tarma	9,460	7,501
Huancavelica	14,700	9,224
Ayacucho	1,050	4,960
Pasco	2,250	10,701
Huanuco	17,440	17,068
Total	60,000	66,413

Source: Graber, E. 1974:16.
Min. de Agricultura, Proyecto PADI, 1986.

Potato technology and production systems vary from one agroecological zone to the next. The cropping system, inputs, tools and machinery (if any), varieties, quality of seed and production objectives will also be different for specialized seed producers, cooperatives, medium-size commercial producers, and small-subsistence farmers. In absolute terms, the overwhelming majority of production units are part of a minifundio system, as in the rest of Peru. Most farmers plant less than 1 ha and depend entirely on human labor and animal force (Graber, 1974:12). Nevertheless, a very important sector of medium-sized and larger farmers exists using modern technology and with main responsibility for supplying Lima.

1. Mantaro Valley: The Production System

The Mantaro Valley of the central highlands has been intensively studied in terms of both production and post-production systems (Franco et al., 1979; Werge, 1977, Horton, 1983). As throughout the Andes, agriculture depends basically on the rainfall-frost cycle. The composition of crops varies in accordance with the altitudinal floors which ranges from 3,200 and 4,200 m.a.s.l. On the valley floor, a complex of crops is found which becomes less diverse as altitude increases (cf. Mayer, 1981). Twenty eight percent of the total cultivated area is given to potatoes (Censo Agropecuario, 1972), one of the few crops which can be planted in all altitudinal zones. Mayer (1981) has differentiated three agroclimatic zones: low zone (3,200 to 3,450 m.a.s.l.), intermediate zone (3,450 to 3,950 m.a.s.l.), and high zone (above 3,950 m.a.s.l.).

a. Low zone. The low zone is made up of both sides of the river and is characterized by level topography. The risk that temperatures below 2° C occur is at one percent during December to April, thus the risk of frosts during the critical growing period is low (Franco, et al. 1979:33). In this zone, Franco et al. (1979) distinguished three types of potato producers: (1) small producers (below 0.5 has) who produce mainly for home consumption, (2) medium producers whose objective in production is mainly to sell consumer potatoes, and (3) seed growers (semilleristas) who produce basically seed for sale on the coast (see Auroi and Vilca, 1985 for a study of seed producers in the Central Highlands).

b. Intermediate zone. The intermediate zone on the east side of the river is characterized by varied soils, moderate and pronounced slopes and rainfed agriculture. Rainfall is 707mm per annum and the chance of frost (at below 0.4°) during the critical periods is high: 10% in October and 12% in November (Laive Station 3,900 m.a.s.l.), increasing risk with altitude (Franco et al., 1979:36). In the intermediate zone on the west side of the river, the slopes are more moderate than on the east side and the amount of rainfall is less. The risk of frosts is higher than on the east side.

c. High zone. The high zone is formed by small cultivated areas above 3,950 m. Although no meteorological data are available for this area, the risk of frost and rainfall is no doubt higher than observed at Laive Station (Ibid. p. 38-39). In the intermediate and high zones, the

average size of holding is less than 2 has and the average cultivated area with potatoes is around 0.5 has (Ibid. 68).

2. The Storage System

Understanding the objective of farmers' production is relevant for analyzing storage systems. In the lower Mantaro zone, the majority of farmers orient the major part of their production toward the market. Commercially specialized seed producers sell 86% of their produce, 58% of which is sold as seed. Percentage kept for seed for the following growing season are constant in all cases (11 to 15% of production).

Potatoes stored for home consumption represent 16% of total production among medium sized producers of the low zone, 31% among the producers of the left side of the river, and 66% among those of the right side of the river and the small producers of the low zone (Franco et al., 1979). Average amount destined for home consumption among seed producers was 10 tons per producer, which is 2% of the total production. This figure includes the families consumption as well as the workers share and the potatoes used for fodder (Ibid. 63).

The type and amount stored is related to production, market, and household consumption needs. Following harvest, highland potato producers select potatoes: papaextra and primera (the largest ones), segunda and tercera (intermediate sizes), cuarta (very small potatoes), and some times chancho potatoes which often are damaged or diseased. The largest tubers mostly go for the market. The intermediate size potatoes are kept for seed and home consumption, and the cuarta and chancho potatoes are reserved for processing (chuño, papaseca, tongosh) or animal feed (Werge, 1979; Prain and Uribe, 1986).

Tuber selection and destination vary with type of farmer. Among highly specialized farmers, such as seed producers, size of seed (generally second quality tubers) is more respected. Small farmers, however, due to cash needs tend to sell their second quality tubers as ware potatoes and keep the smallest tubers as seed (third-fourth quality tubers).

Storage of seed potatoes in the highlands is very important since farmers buy new seed every 5-6 years, even up to 8-10 years (Franco et al., 1979). Coastal potato producers, on the contrary, are obliged to buy seed every year or every 2 years if they use criolla seed (see Prain, n.d., for a more recent study of potato seed systems of Central Peru).

Highland storage patterns vary in length according to cropping cycles in each zone. During the 1977-78 season in the Mantaro Valley, 58% of the parcels (Franco et al., 1979:81) were planted with home-grown seed stored in rustic stores. Seed purchase depends on how degenerated or "tired" the seed becomes, as understood by farmers. Use of home-grown seed increases in the higher zones of the Mantaro Valley. This is partly due to influence of altitude on seed quality but also to socioeconomic factors such as purchasing power or access to new seed sources. Some highland producers plant potatoes at different altitudes and rotate seed in order to prevent degeneration.

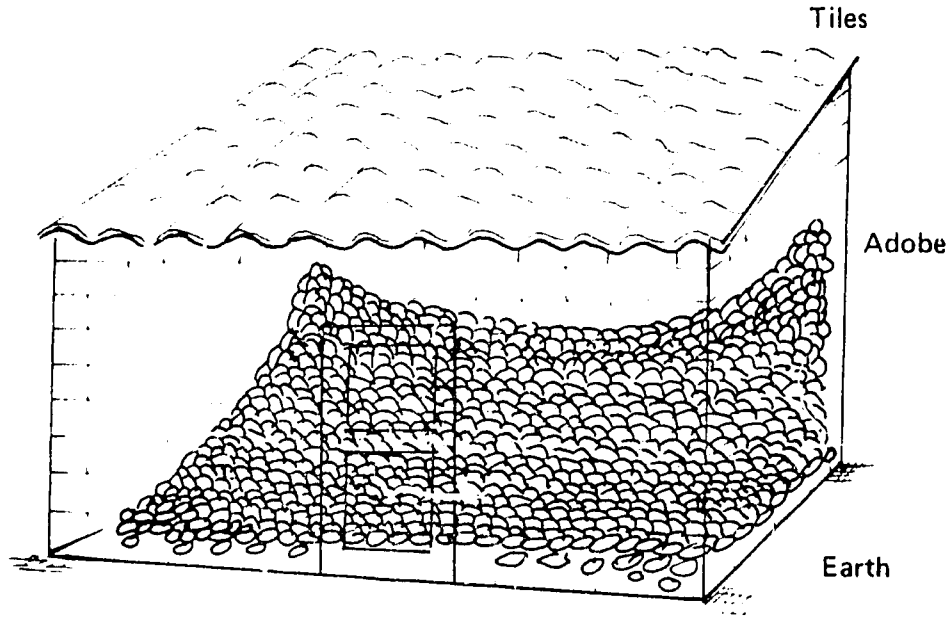
Potato varieties, which vary in accordance with agroecological zones and farmers' technology, are an important element in storage. In the low zone, 87% of the parcels of small and medium sized producers were planted with improved varieties such as Renacimiento, Mariva, and Revolución (Franco et al., 1979). Renacimiento was introduced more than 20 years ago and has been maintained due to its good storage and transport qualities although it is a late maturing variety. Low zone seed producers planted more varieties than smaller farmers in 1979, with a total of 13 varieties reported. Among them, Renovación and Renacimiento are sold mainly as consumer potatoes, the remainder for seed. The most generally used varieties among the seed producers are Mariva, Ticahuasi, Yungay, Antarqui, and Cusco, which occupy the largest portion of the planted area. Franco et al. (1979) note that these improved varieties were least valued for their storage characteristics, especially Mariva and Ticahuasi. Other varieties: Revolución, Tomasa Condemayta, Mi Perú, and some native varieties are planted on a smaller scale (Franco et al., 1979:58).

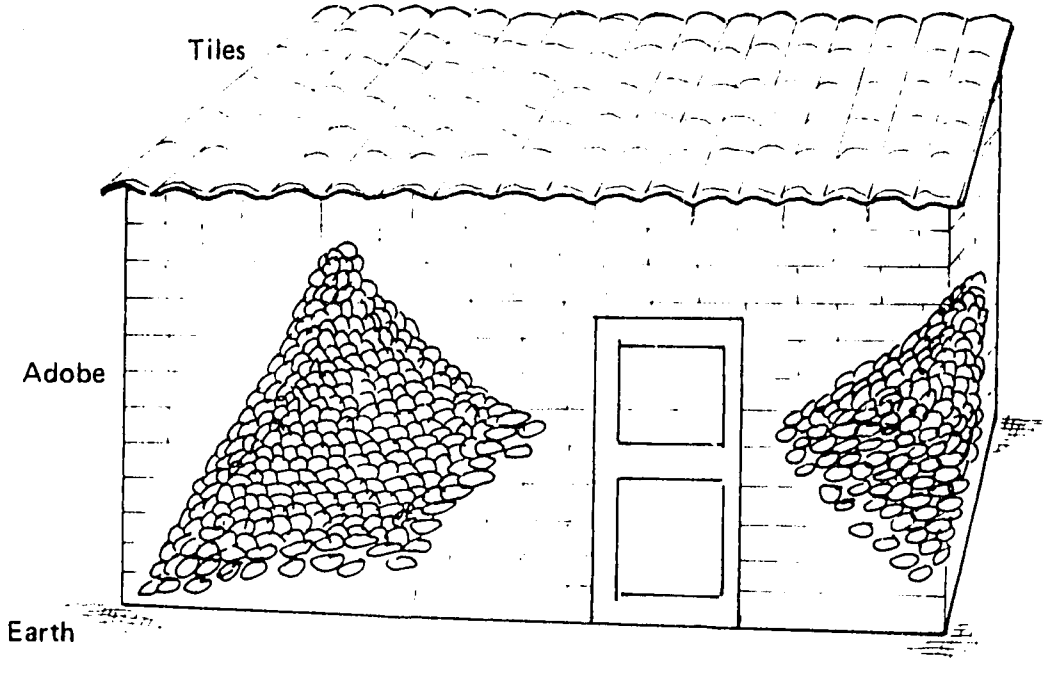
In the intermediate zone, Franco et al. (1979) report a roughly equal portion of native and improved varieties planted. The diversity in the intermediate zone is higher in native than in improved varieties though there is a wider range of improved varieties here than in the low zone (Prain, 1987). The native variety Huayro is the most widespread.

In the high zone, cultivation of native varieties predominates especially varieties of bitter potato (shiri, etc.); 56% of the fields were planted in native varieties (Franco et al., 1979: 43). Many farmers plant native varieties in mixed stands but in storage each variety is separated (Hugo Fano, 1986, personal communication). Traditional storage systems may have been relatively effective with native varieties produced and stored in the higher, cooler zones. Due to a lack of "cultural experience" in handling improved varieties with short dormancy periods and produced largely in the lower zones, problems in storage during the last two decades arose. This can be illustrated with the data obtained in the Mantaro Valley where 40% of the farmers interviewed confirmed having problems of storage (Franco et al., 1979:106). However, efforts by the International Potato Center to test through controlled comparisons the storability performance of improved and native varieties have not been conclusive.

a. Seed storage. The most common form of seed potato storage in the highlands is on the ground floor in dark or semi-dark stores, or inside houses. Only in zones where no robbery occurs are potatoes stored in the field. The stored potato seed is piled into trojas (small bins) or a granel (in piles that may reach 1.5 meters) (cf. Werge, 1977, 23-24). In some cases, muña (Minthostachis mellis) or eucalyptus are used as insect repellents. Leaves and branches of these aromatic plants are placed on the ground before the seed is stored. Insecticide powder is commonly used as well.

Figure 9. Seed storage in the highlands





Highland house architecture, which is characterized by few windows, allows little opportunity for diffused light seed storage. Construction material most commonly used is adobe; the roofs are of straw or tile, or in some cases, corrugated sheet metal. Some light enters through windows, doors or spaces between the walls and roof. However, farmers often prefer to look for the darkest place in the house to keep seed. Roofed and shaded places are cool even during hours of highest temperatures.

The form of storage of seed tubers also varies with the type of producer. Medium and large potato producers --given the volume of seed which they need to store-- use various rooms to store seed (Werge, 1977: 26). In these cases, seed is heaped up into piles of up to two meters in height, thus reducing the light effect on tubers which are not on the surface. The smaller producers on the other hand, use dark or semi-dark rooms which have, at the same time, other uses as well. In this case, tubers may be placed on the ground or kept in sacks. In a recent study (Prain, 1987) 25% of informants stored part or all seed in sacks.

Inside the stores, seed is separated by variety, size, and harvest time so that they can be easily recognized. Amounts stored depend on the extension to be planted with potatoes. Small producers generally store less than four tons of seed each year. In the highlands, the majority of producers plant small areas in potatoes (less than two hectares, cf. Table 3). Large farmers have been found to store up to 160 tons of seed.

Storage length of seed potatoes varies and depends in each zone on the cropping calendar. This, however, will not be less than 4 months in non-irrigated areas where storage begins after the May or June harvests and lasts to plantings between September and December.

In the Comas Valley, which lies to the west of the Mantaro Valley, absence of frosts and presence of humidity allow early planting in July on the valley floor until the month of September in the higher part of the valley. Harvest starts in December and continues through May. Seed is obtained from the last May harvest when rain is over as farmers argue that wet tubers are not suitable for storage. As a consequence, storage periods are shorter than in the Mantaro Valley.

In Pampas (Huancavelica) as in most highlands areas, staggered planting is practiced in different altitudes from the valley floor to the highest parts in order to avoid frost and other climatic risks. The diversification is even accentuated due to the availability of irrigated terrain. Planting is during July and August on irrigated lands, and during October and November on dry lands. The harvest occurs from February to April (irrigated land), and from April to May (non-irrigated land). Tubers of the last harvests are kept as seed thus reducing the storage period. In this case, seed is stored a minimum period of two months.

The most apparent problem in storage of seed tubers is insect attack, primarily tuber moth, which was pointed out most emphatically by farmers in Comas (cf. Egoavil, 1985). The rapid growth of sprouts in early maturing varieties such as Mariva, was indicated by others. However, for

the late varieties or the semi-late ones, the size of sprouts and the dehydration of the tubers has been pointed out for the Mantaro Valley (cf. Franco et al., 1979:106). Traditional storage of seed tubers is such an ancient practice in the highlands that producers are culturally used to the physiological characteristics of traditionally stored potatoes that it is difficult for them to view "problems." During our study storage "losses" per se were stressed very few times (cf. Werge, 1977).

The recent success of developing and transferring to farmers the use of the diffused light storage principle in the Central Highlands by the national research and extension service in collaboration with CIP is most likely related to a need for improved storage of improved varieties and the fact that more potatoes are being produced in the lower, warmer zones (Schmidt et al., 1984). Storage is a technology which changes more slowly than other aspects, such as varieties. There is a technological "lag" which implies that as varieties change, traditional storage practices may become inappropriate. The diffused light technique, with its capacity to help reduce sprouting and improve tuber quality, was a way to simply and inexpensively adjust seed storage to the new storage demands of improved varieties in the interandean valleys. It is important to stress, however, that diffused light storage technique is not appropriate for producers who deal in large volumes, e.g. over 100 tons, or for very small producers who store all potatoes in darkness in case they have to eat them at times of food scarcity or market them as ware potatoes. Space and theft are also major problems for small producers. It is also inappropriate in areas where almost continuous production is possible and where only short storage periods are necessary.

b. Storage of potatoes for home consumption. In the highlands, part of the harvest is stored to cover family consumption needs between one season and the next. Special care is taken in storage since potatoes are the staple food of the rural population. The most common and secure means of storage for home consumption occurs inside the houses of farm families. These can be (1) terrados (terraces), and/or altillo (attic), or (2) in rooms.

- Terrados, altillos or áticos are formed by a platform a short distance from the roof. This platform can be constructed of wood, eucalyptus trunks, reeds (caña brava), in order to increase ventilation, a principle farmers know well. For storage, the terrado is covered with ichu grass and muña (Minthostachus mellis). Potatoes are placed on top of the natural pest repellents, selected by size and variety, in piles of 0.5 to 1 meters. Sometimes potatoes are covered with jute sacks to protect them from light. These terrados are practically dark since the lack of windows does not allow light to filter in.

- Rooms in the house that receive little light are carefully selected for storing consumption potatoes. Absence of light in storage of potatoes for home consumption is very important as greened potatoes become bitter and inedible. The potatoes are placed directly on the floor or sometimes in tarimas (platforms) on straw, muña. Potatoes for home consumption are also kept in field stores, but this is less frequent due to the danger of robbery.

Storage period for consumer potatoes, like seed potatoes, varies in accordance with the cropping calendar. In the Mantaro Valley, for instance, harvest on non-irrigated land takes place beginning in April-May. Potatoes for home consumption are stored for 6 to 7 months from the last harvest in June and should last until December or January when "new potatoes" from early varieties become available or can be purchased from low zone irrigated harvests. Home consumption storage is longer than for seed potatoes.

Storage of table potatoes is an activity that requires special care from the whole family, especially women who are in charge of the operation. Through careful selection, all damaged tubers are discarded. Potatoes are then grouped by size and variety. The storage facility is then cleaned and desinfected, mainly against insects. Muña as well as insecticides can be used for this purpose. Once potatoes are stored, handling is reduced to a minimum. We were told by farmers "when table potatoes are moved, they turn black so that not even the pigs will eat them."

Toward the end of the storage period in December, potatoes are generally dehydrated, wrinkled, and heavily sprouted. However, "shrivelled potato" or "old potato" is appreciated for a sweet flavor. One folk saying illustrates this culinary preference: "sprouted potatoes are tasty as figs." These aged potatoes are typically boiled since they cannot be peeled for soups, stews or frying. Instead "new potato" is especially purchased for these dishes.

Amount of potatoes stored for home consumption depends on the duration of storage and the number of persons in the household. In broad terms this fluctuates from a minimum of 500 to a maximum of 1,000 kg per year per average family.

c. Storage for future sale. Potato storage explicitly for future speculative sale is found in the Mantaro Valley but only rarely (Franco et al., 1979:106). Possible reasons are: (1) risk there will not be a significant price hike which would compensate for storage cost and loss in weight and quality; (2) need to pay off credit debts at time of harvest (cf. Maxwell, 1982); (3) need for cash at harvest for next planting, purchase of non-farm produced items (kerosene, clothing, etc.). Nevertheless, among small producers women store small quantities as a kind of "bank account" which later they sell in limited and staggered quantities when they need money (para el gasto).

3. Storage Practices and Problems in a Peasant Community: Palca[2]

In this section, we turn from more general considerations of highland storage to an in-depth examination of storage practices in a single highland community. Palca, located in the Province of Tarma, Department of Junin, controls lands stretching from the high zones down to the Chanchamayo Valley in the high jungle. Within the larger community are

2 This section is based on Egoavil (1985).

found several smaller satellite communities. Located on the central highway transversing the central Andes from the Chanchamayo to Lima and favored by excellent lands for production, Palca has over the past two decades become specialized in potato production, mainly for the Lima market. The following results are based on a study by Egoavil (1985), as part of CIP's post-harvest technology and management research. The unique contribution of this research, of which only the major findings are reported here, is the differentiation of storage strategies between three types of producers: small, medium, and large. Also, differences in storage practices and problems in the major and minor production seasons are discussed.

a. Production and storage. During the 1982-83 agricultural campaign, 140 has of potatoes were planted in Palca, a community where the potato has become a production specialization of farmers. Among community members, medium size farmers cultivate the greatest extension (38% of total potato area) with an average of 2 has per family, followed by small peasant growers (34%) with 1 ha per family. The large growers (28% of total area) average 3 has per family. For the community as a whole, the peasant family plants an average of 1.5 has which is indicative of the high fragmentation of land control in Palca (see Table 5).

Table 5. Potato area and yield in Palca, 1982-83

Strata	Households		Area planted			Yield		
			Total		Per household	Total		Per household
	No.	%	has	%	ha	tn	%	tn
Large	13	14	39.2	28	3.0	314.3	28	24.2
Medium	27	30	53.0	38	1.9	417.5	37	15.5
Small	52	56	48.3	34	1.0	406.8	35	7.8
Total	92	100	140.5	100	1.5	1,138.6	100	12.3

Source: Egoavil (1985)

Two plantings take place in Palca: an early planting from May to August and a normal or main planting from August to November. In Palca, 6 sectorial rotations (turnos) in the early planting are found and 5 in the normal period. The sectorial system is a communally controlled fallow/rotation patterns involving crops and livestock and in which a sector is planted every 5 to 8 years. During the normal or main period, peasants store for home consumption and seed more than twice the amount of the early planting. However, a greater proportion is sold from the early planting to catch better prices on the Lima market. Most potato seed used is locally produced and stored. In years of low or scarce production, small producers buy seed from middle and large producers. The primary varieties are: Yungay, Mariva, Revolución, Tomasa Condemayta, Antarqui, and Participación.

Photo 8. Community of Palca, Department of Junin.

Photo 9. An interview about sprout length after storage.

The peasants of Palca recognize that potatoes of whatever variety harvested in the main period are more appropriate for storage than potatoes of the early harvest because they are produced in dry fields and of better quality (i.e., less disease and pests). This is especially true of Yungay, the main variety in 1984.

Small producers have a greater number of fields to plant early and thus need to keep more seed, although they run the risk of shrinkage. The normal harvest is sometimes delayed, a form of natural storage in the field waiting for improved prices.

b. Destination of the potato crop. Palca is strongly linked to the commercial potato market. The greatest part of production is destined for the central region and Lima markets, the latter absorbing 64% of Palca's total production. Palca families on the average store 26% of the total volume of potatoes, sell 64% and use 10% for animal feed (see Table 6). Nevertheless, the three socioeconomic strata of producers --small, medium, and large producers-- each have different destinations and uses for their produce.

Table 6. Average volume and percentage of potato stored, sold, and used as animal feed, according to size of producer in Palca

Strata	Stored		Sold		Animal feed		Total	
	x tn	%	tn	%	tn	%	tn	%
Large (n=13)	5.08	26	12.2	62	2.45	12	19.73	100
Medium (n=27)	3.82	25	9.85	65	1.43	10	15.11	100
Small (n=52)	1.75	26	4.55	66	.53	8	6.84	100
Total (n=92)	2.83	25	7.18	65	1.07	10	11.08	100

Source: Adapted from Egoavil (1985:77). Figures do not include potatoes used to pay off laborers or consumed at harvest.

Large producers distribute their production in the order of descending importance: (1) sale to Lima of consumption potatoes, (2) sale to Cañete of seed potatoes, (3) sale to mining zones of Casapalca, La Oroya and communities of the high jungle, (4) seed for their own use, (5) consumption potatoes for feeding permanent and temporary laborers, (6) family consumption.

Medium-size farmers divide their harvest: (1) sale of consumer potatoes to Lima, (2) storage of seed potatoes for own use, (3) consumer potato storage for family consumption where sporadically and in certain cases according to their cash needs, norms and sociocultural relations and of parentesco sell to the local market, barter for products of the jungle

(cassava, fruits, etc.), also for giving as "gifts" to their family members, sending to Lima and other neighboring cities of the village, (4) sale of seed and (5) sale for animal feed.

Small producers divide their harvest: (1) potato for family consumption, from which on certain occasions, small amounts of papa seca are processed as gifts for family members or for later barter, (2) storage of seed potato for own use for the next season, (3) sale of seed potato in small amounts, (4) sale of consumption potatoes to middlemen who carry to Lima and other regions and extra-region, (5) discard tubers for animal feeding.

The tendency of the 3 strata combined is to sell more than they store (114 tons of consumption + 147 seed stored vs. 401 tons for sale). Comparatively, small producers on the average keep for home consumption more than twice the amount (48 tons) of large producers (22 tons). Medium-size producers store more seed (59 tons) than the large growers (44 tons) and small producers (43 tons). Peasants participate in the market as purchase and consumers of products such as sugar and kerosene. To meet these needs they gradually "unload" their stores little by little for market sales thereby reducing the available amount for family nutrition.

- Sale of consumer potatoes and seed. Percentage of total production sold immediately at harvest in the early planting is greater than in the main harvest since "early" potatoes are not suitable for storage since they are harvested in the rainy season. Producers sell 65% of their available production in regional markets and extra-regional market. The Mercado Mayorista (wholesale market) of Lima absorbs most of the harvest. Seed is taken to Cañete and neighboring villages or is sold among Palca producers when seed is locally insufficient. Of the total Palca production sold to merchants (middlemen), 50% comes from small producers, 35% from medium size, and 15% from large producers.

  Basic reasons for immediate sale of potato after harvest are: (1) strong need for disposible cash for family expenditures; (2) avoid loss of weight; (3) potato harvested in "early" harvest cannot be easily stored; (4) storage period of the "early" harvest is technically difficult.

  Secondary reasons given by farmers are: (1) obtain good prices in the Lima market; (2) need to repay production loan from the Agrarian Bank; (3) unavailability of technically modern stores; (4) lack of space in stores and to avoid loss; (5) storage is not profitable due to losses of dehydration, rotting, sprouting, and attack of insects and other pests (according to 16% of the sample).

  Tertiary reasons given are: (1) to purchase and stock up inputs and fertilizers for the following campaign; (2) harvest in the rainy season "early harvest" does not store; (3) to avoid greening or spoiling; (4) avoid worms damage in the regular period.

- Storage of consumer potato for family consumption and seed potato for own use. Small producers in particular and a few of the middle strata, keep potatoes for family use and to distribute later for various

reasons: (1) for payment in "kind" to family members and friends for work and/or services; (2) barter for maize, fruit, sheep hides, and in some cases, industrial products during periods when households have no cash; (3) gifts to family members and visitors as a form of reciprocity; (4) later sale in the local, regional or extra-regional markets, according to cash needs; (5) fullfil community obligations such as fiestas (civil-religious) or family obligations, such as padrinazgo.

The storage distribution rationale of small producers is to maintain a proportional equilibrium in use of seed potatoes for the next planting and of consumption so that they store more or less in equal amounts of both. Families with greater production proportionally store less of their harvest than families that produce little (23% versus 55%).

c. Typology of storage facilities. Producers planting less than 2 has typically store in-house, together with grains, farm implements, and other agricultural inputs. Producers planting greater than 2 has tend to store potatoes outside the family dwelling in special storage facilities. Some large producers have several stores at different locations where they are not able to carry out good management. These producers indicated better control could be accomplished in a single, large store, but did not consider this profitable due to the high cost of new construction.

- In-house stores are, by definition, located inside regular farm houses. The medium-size producers have the greatest problems of space since their stores serve several purposes, including crop, tool, and fuel storage along with housing of domesticated animals. Typical in-house storage systems in Palca are:

  - The graneles. Eighty percent of Palca farmers store in piles, over the soil and against the walls of a corner, containing the potatoes with adobe, wood, or rocks. The piles can reach heights of 2 meters. Producers residing in far away barrios store potatoes below the bed, reaching pile height of approximately 60 cm. To avoid shrinking and wrinkling but without drying out potatoes, seed potatoes are placed elevated above or protected from touching the ground directly. The greatest problem of graneles is the lack of proper ventilation.

  - Altillos (attic): Consumption potatoes are placed over a base of carrizos and covered with sacks of polyethylene, jute sacks or straw. The roof always has openings that permit the entrance of light and ventilation. The potato is stored in the attic with other harvested crops.

- Stores separate from the house are:

  - "Galpones" or rustic silos. Constructed with adobe, eucalyptus wood, galvanized tin roof, and with a floor of soil, galpones are open on three sides and separate from the family dwelling. Potatoes are placed in piles of 75 cm.

- Field stores. The choza is the classical prototype of traditional storage constructed with bush sticks with a roof of staw or loneta. Here, farmers store temporarily for some days until the end of the harvest.

d. Storage practices and periods

- Pre-harvest activities. A few producers with experience consider storage aspects prior to harvest. To avoid fungi or other diseases, these producers do not harvest potatoes when they are immature, but cut the foliage approximately 2 1/2 weeks before harvest. Some large producers indicate that haulm cutting helps increase the capacity to resist damage during loading and manipulation.

- Practices at harvest. Producers wait until the opportune moment for harvest, when the vegetative period has ended. When harvest occurs on hot and humid days, potatoes are left for a short period to dry. To avoid greening, potatoes are protected from the sun.

- Pre-storage management. (1) Fumigation of stores with chemical products and specifically space where potatoes will be placed (77% of total interviewed); (2) desinfect seed (20%); (3) use muña as natural repellent (20%), and (4) only clean space utilized for storage (11%).

- Storage periods. The average storage periods for (1) seed: varies between 3-4.5 months for early planting and 2-4.5 months in the normal period; (2) consumption potatoes: varies between 3-4 months in early planting and 2-4 months in the normal period. The staggered plantings in the distinct sectors (turnos) in both periods determine that storage for any period is not long.

Palca producers know the potato suffers water loss by evaporation. Sprouting is partially perceived as a problem. Farmers note that sprouting quita la fuerza a la papa ("takes the strength from the potato") or se va lo mejor de la papa ("the best goes to the sprout"). The amount of sprouting is variable between communities. Excessive sprouts in consumption potatoes are especially notable in high zones such as Churupata and Nahuin.

Seventy-two percent of producers prefer to store seed potato with indirect light while only 28% store in darkness. Field observations, however, showed that 50% of the producers leave the doors of the store open or half open during the day, closing them at night. Also, even in dark stores, light filtered through windows and openings between walls and the roof. Some producers "green" seed in the sun when the conditions of storage are still not appropriate. Farmers make sure home consumption potatoes do not "green" since it lends a bitter taste that is, in their words, "not even good for cattle".

e. Losses in traditionally stored seed potato. In the "early" planting, larger producers have the greatest losses (47%), medium producers have 37% and small producers 16%. During the regular harvest, the

greatest losses are acquired by the medium size producers (54%) and almost equal amounts the large and small producers (23%).

In both periods, main losses are due to tuber moth. The attack of tuber moth was less with small producers because their stores are in the altura (high zone) where there are lower temperatures and greater ventilation. Twenty percent of those surveyed used muña.

Large producers during the early harvest have problems of "rotting" and rapid weight loss due to harvesting in large amounts and deep piling of tubers of high moisture content. However, in the normal harvest, large producers had the least percentage of loss since they quickly sold potatoes and moved them out of store. The small and medium producer loss greater amounts due to dehydration in the normal period since for these two groups the storage period is longer.

Likewise, in the normal season, harvested potato have a high incidence of worms (Gorgojo de los Andes) which increases storage problems, especially under inadequate prior selection. Losses due to tuber moth were greater than dehydration, rotting and attack of rodents. This may be due to the inadequate use of chemicals (many use Aldrin against tuber moth) and scarcity of muña in the region. The percentage loss in seed due to dehydration can be as high as 60% of weight. In the case of home consumption potato, the losses of weight reach 70% after long periods of storage. Losses of seed for their own use by tuber moth, dehydration, rotting, and attack of rodents in the early period were less (10%) than the normal harvest (17%). It is very possible that the registered percentage (15%) in loss of seed potato might have been underestimated by producers themselves.

Table 7. Losses in seed stored for own use in the early and normal harvests (%), Paica

Strata	EARLY					NORMAL				
	Tuber moth	Dehydration	Rotting	Rodents	St.	Tuber moth	Dehydration	Rotting	Rodents	St.
Large (n=13)	8.74	10.83	1.90	.04	21.41	2.74	11.50	2.04	.53	16.3
Medium (n=27)	22.81	.23	1.05	.12	24.21	12.86	3.51	.80	.05	17.7
Small (n=52)	2.87	4.13	.13	.13	7.25	8.81	5.56	1.34	.28	15.8
Average all strata	10.20	5.53	1.00	.09	16.77	9.38	6.00	1.23	.28	16.9

Source: Adapted from Egoavil (1985).

f. Valuation of stored potatoes. Villagers, especially small producers, often consider stored potatoes as "reserve capital." According to Egoavil (1985) they are not able or willing to emphasize the monetary significance that storage assumes for the domestic unit. They assign monetary value only when the product is ready to be exchanged on the market. This may also be because farmers are frequently reluctant to assign a monetary value to someone administering a questionnaire, since storage for speculative purposes has been ruled illegal by the national government several times in the past decade.

V. Storage in the Southern Sierra

The southern highlands --especially departments of Ayacucho, Apurimac, Cusco, and Puno-- is economically the poorest rural region of Peru. Also, despite many similarities conditions for production and storage differ from those of the central highlands. The case of the department of Cusco is especially relevant since, unlike the other departments in the south, valuable statistical information and research on potato agriculture are available (e.g., Franco, et al., 1981). This section will concentrate on farm-level storage. An ENCI national store is found in Anta-Chimpahaylla which holds 5,000 tons but, like other large stores in Peru, is not in use.

1. The Production System

As in the central highlands, potato production of Cusco stretches over a wide variety of irrigated and rainfed agroecological zones, ranging from 2,500 meters to approximately 4,200 meters. This variety of production zones explains the existence of an extended planting season of seven months, from June to December and an even longer harvest from November to July. There are three periods of planting. The first is called mahuay (early, irrigated season) followed by the chaupi mahuay (semi-early either in irrigated or non-irrigated lands with high moisture content) and finally, the hatun tarpuy, which is the main season begins in October (Franco, et al., 1981: 30). In general, the farmers, especially the small ones, practice the three plantings whenever possible as a strategy to spread risks.

Table 8. Socioeconomic characteristics of potato production: Cusco

	Valle Sagrado	Anta Maras		Urcos Andahuaylillas Acomayo	Cusipata Tinta Sicuani
		Small	Medium		
No. of potato fields per producer	1.14	1.85	2.16	1.21	1.66
Potato production by producer (t)	1.24	1.46	12.98	0.91	1.38
Area under potato by producer (ha)	0.25	0.47	1.88	0.35	0.31
Potato yields (t/ha)	5.00	3.1	6.91	2.63	4.37

Source: Franco et al., 1981: Table No. 2.

Nine months of continuous harvest imply that the regional market is sufficiently supplied. Between September and November, the supply from the field of both consumer and seed potatoes decreases. Potatoes which then come on the market are derived from rustic stores. Although harvest of improved varieties for the urban market period begins in November, the largest quantities are harvested during January.

Although planting in the three indicated seasons is a common practice among all farmers, percentage planted in each one will differ. All farmers plant in hatun tarpuy, the main season, while only farmers with irrigated land will plant in mahuay. Storage of potatoes will thus depend on type of farmer and agroecological conditions of specific plots.

Small farmers cultivating less than 1 ha form the largest group and were found in all ecological zones by the Franco et al. survey (1981:23). Medium farmers (1-5 ha) were also found all over but in less numbers. A few large units (cooperatives or agrobusinesses) were found planting more than 120 ha with potatoes.

Although Franco, et al. (1981:53) notes that "among the small producers, the major part is used for home consumption ..." up to 40% of the hatun tarpuy production is sold. As the individual amount of potatoes produced by the majority of farmers is very small, sales are also very small: up to approximately 500 kg per unit.

Farmers who orient their production to the market in sizable amounts are the medium-sized farmers, cooperatives and agrobusinesses. Likewise, the amounts of seed stored by these two groups are also larger. The proportion given to consumption, sale, and seed does not only depend on type of producer but also on time of planting and production zone.

A very important difference between the central highlands and the southern highlands is that the improved varieties are dominant in the first case, while in the second case, native varieties prevail. Seventy-five percent of the area planted in the sample of Franco et al. (1981: 32) was with native varieties. Similar information was revealed in the census data of the Ministry of Agriculture (cf. Table 9).

Approximately 60% of the fields are planted with home-grown seed tubers and 40% with purchased seed (Franco et al., 1981:34). In the low zones, the percentage of purchased seed is higher and the producers change and renew their seed more often than in the higher zones, owing to what farmers call cansancio (tiredness) or degeneración (degeneration) of the seed. This indicates that the role of seed storage is at present more important in the high zones than in the low zones.

Farmers keep between 15 and 20% of their production as seed. Of this amount, a small portion is sold and the larger part is used in their own fields (Franco et al., 1981:50). The size selected is termed "second" or "third" which have a lesser weight than those called "second" and "third" in the central highlands. Only the medium size producers and cooperatives store large amounts of seed.

Table 9. Cusco: Areas planted in native and improved varieties

Varieties	Area Planted
Improved	
Renacimiento	3,602
Mariva	1,744
Others	910
Total	6,256
Native	
Ccompis	11,806
Imilla Negra	4,202
Duraznillo	1,599
Huayro	1,333
Olones	1,010
Others	2,173
Total	22,123
Total (improved and native)	28,379

The technicians of the Ministry calculate approximately 34,000 has as the real total area planted in the IX region.

Source: Ministry of Agriculture IX Agricultural Region. 1980-81 season.

2. Storage System

The physical and technical characteristics of storage are roughly the same as reported for the central highlands. The main form of storing potatoes, seed tubers as well as for consumption, is in the house and under dark conditions. The storage in large rooms or bodegas, as termed in the Mantaro Valley, are used exclusively by cooperatives, farmer groups, communal enterprises, and medium-sized producers.

a. Storage strategies. As in the central highlands, the potato in Cusco serves for self-consumption, sale at the market, seed, exchange for labor and for petty cash (para el gasto). The amount kept and stored by small farmers is generally very small. The average area in potatoes per small producer varies from .25 to .5 has, which gives us an idea of the small quantity of seed which is stored yearly. If half a hectare is planted in potatoes, 300 to 400 kg are stored for seed. Farmers describe these quantities in cargas: one carga equals five arrobas, five libras.

Storage of potatoes for home consumption also includes potatoes destined for el gasto or petty cash, to buy certain inputs and products that are produced outside the domestic unit (e.g., sugar, candles, oil) as was

found in the case of small producers in the Central Peruvian Andes. Households surveyed store an estimated 500 kg for 2-8 months for gastos, a figure which roughly corresponds to the amounts estimated for the central highlands. It is difficult to assess the quantity of potatoes destined to this transaction as this sale is not regular and is based on particular family needs.

Potatoes for future sale are sometimes stored in sacks up to 4 months or piled in rooms awaiting better prices or until petty cash is needed. This practice is possible only if the farmer does not have credit commitments forcing immediate sale. Sale to obtain petty cash could be done as late as October/November (5 months storage as a minimum) without suffering a reduction in price, given that no "new" potatoes entered the market (Schmidt, 1984). The potato "domestic bank" is controlled by women who take, according to need, small amounts to local markets for sale along with other produce from their stores.

As mentioned above, there are at least two plantings a year in Cusco: (1) the early planting or mahuay on irrigated land can last from March through August and is mainly destined for sale as it is harvested during the rainy season and tubers are wet, making their storage more difficult; (2) from the main season or hatun tarpuy (October to December) seed, potatoes for sale and home consumption will be selected. Potatoes for home consumption should last until the mahuay harvest.

Farmers are very aware of the problems that a prolonged storage period might cause. Through years of experimenting, farmers have used and selected a number of varieties, mainly native landraces, which responded positively to that challenge. Native varieties, Ccompis for instance, have been cultivated for hundreds of years and are preferred, due to their long dormancy periods for long storing.[3] Another positive feature of native varieties is their high content of dry matter that with time and dehydration becomes "sweet" thus making it preferred consumption even after it is old and shrivelled. Some farmers believe improved varieties (like Mariva, Micaela Bastidas) on the contrary, end up bitter, blackened and even with hollow heart (Schmidt, 1984).

Present storage problems do not reflect entirely the mismanagement by farmers of the environment or physical conditions of storage. Many storage problems may be due to the ever larger presence of improved varieties that represent higher yields but have shorter periods of dormancy which make them difficult to be kept more than 4-5 months in traditional stores. Chemicals sprout inhibitors (Nobroton) are increasingly being used to control sprouting, a technology adoption affecting storage design and location. Use of muña is still widespread as a repellent.

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3 In the XVIIth century cconopas (objects made of stone or clay representing a plant or animal from which successful harvests or breeding was desired) representing the variety Ccompis were found. Joseph de Arriaga. La extirpación de la idolatría en el Perú. Tomo 1, 2a serie, Lima, 1920. Whether this is the same variety as the modern one of the same name is not known.

The drought of 1982-83 brought about a reduction in area planted in Cusco, causing a reduction in amount of seed stored. However, a recent maize disease poncho rojo in the Valle Sagrado has brought producers to rely more heavily on potato. People are now planting potato earlier, in the former period of maize planting. This way the production mahuay is increasing and potatoes are appearing earlier on the market. Storage strategies are constantly being altered to adapt to changes in the production cycle.

b. Types of storage in the Department of Cusco

- In-house storage

  - Troqes. The most common in-house storage practice in Cusco (excepting Paucartambo where kawitos were found to be more widespread) is in troqes (or troja; cf. Werge, 1977) made out of adobe bricks having an average capacity of 1 m^3. These troqes are in the house, in dark, fresh rooms and are used for both seed and table potatoes which are put on a thin bed of straw. Very little eucalyptus is used in the region (Schmidt, 1984).

  - Taqe means "store," generally a store for grains. This is a circular container of approximately 1.5 meters diameter and one meter in depth, constructed by weaving wheat or barley straw. Branches of bushes can also be used. The taqe is kept inside the house, generally in dark rooms.

  - Kawito is a storage type more commonly found in Paucartambo. This consists of shelves made out of adobe or eucalyptus branches and straw. Superior part is used either as a bed or to store grain and other farm products. The lower part is divided in two: one part for seed (generally the part which would have more light if any) and the other one for potatoes for home consumption. This part will generally be covered with straw.

  - Suncho is a variation of the kawito but made completely with wooden branches. Potatoes are however not put on the ground but on shelves made also from branches. Both seed and table potatoes are stored in suncho.

  - Milk'a or "cylinder" is made out of branches and covered with straw. Seed potato would be less covered with straw than table potatoes.

- Storage outside farm house

  - Some farmers store their potatoes (generally seed) outside the house but within the wall compound in piles covered with straw called pinakancha. Numerous farmers keep their potatoes this way right after harvesting until other farm work will allow them to select their different potatoes (sale, consumption, seed, etc.). This "provisional" storage may last up to 2 months.

  - A variation of the pinakancha are the pirhuas (Photo 11) which are cylindric stores made out of straw and fixed with ropes. Farmers

claimed that potatoes stored in this way could be left outside from May through November (Schmidt, 1984).

- Q'oto. Seed is sometimes stored outside of the house, in a manner called q'oto in Quechua. Anywhere outside (a passage way, for example) but protected from animals and thieves, the seed is heaped up in piles, separated by variety or size and covered with ichu grass. Each pile is small, from 30 to 50 kilos for example (cf. Figure 10). This is another variation of pinakancha, mentioned above.

- Pampasq'a. Potatoes are sometimes stored below the ground, at least in the Paucartambo region (Figure 10). This consists of a rectangular hole (the case we observed measured 4 x 1.5 and the depth of a "man's height"), the floor covered with stones, upon which a layer of ichu grass is placed. Ichu is also put between the walls of the hole and the potatoes as these are place inside. At ground level, the tubers are covered with ichu and at the same level as the fields. This practice has disappeared in the zone Chinchero-Maras-Olones, probably due to introduction of sprout inhibitors and theft.

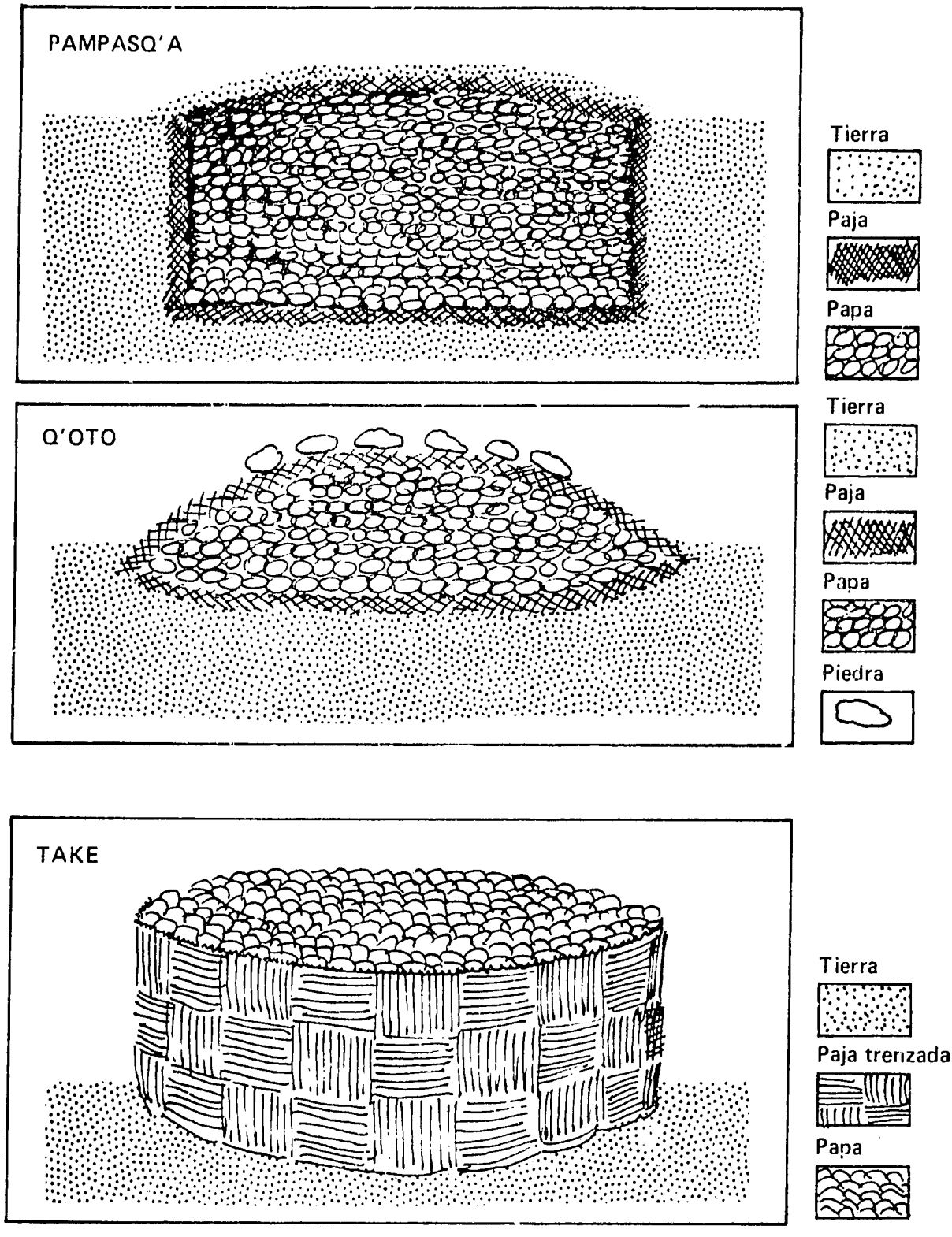
  To construct the pampasq'a care is take to select the location where the hole is to be dug. Farmers select a "dry" area in which the (napa freatica) is deep. One informant called this storage below the ground taparo or tapura pampay. The Cusco system is the same as is called poqullo or huaco in the Mantaro Valley (Werge 1977:30).

  This form of storage is used for seed as well as for ware potato storage. When the prices are not favorable, this system has been used to store part of the production in hope for better prices. A guard often has to be paid to watch the store. Formerly, this was a more common system but with increase in theft, on the one hand, and the practice to sell part of the production, on the other, the preferred practice presently is in the house. Only if the house does not have sufficient room and the farmer finds it necessary to store a considerable amount of tubers might he take recourse to this system of underground storage. In the Cusco region, the underlying rationale of the system is the same as in the central highlands: to store in the field in order to avoid transport.

  A variation of this system is the montonasq'a which consists in forming large heaps of potatoes covered with ichu and soil (same as the pitra of the Mantaro Valley (cf. Werge, 1977:30). In both cases, the store holds seed and consumer potatoes.

- Bodegas. As in the Mantaro Valley (cf. Werge, 1977), storage can take place in bodegas, which are rooms inside the houses, or especially constructed rooms, or in galpones (sheds). The only ones using this form of storage are the cooperatives, farmer groups, communities, and a few medium sized producers. This group of producers generally sells the total production at harvest and does not store seaking speculation. For this reason, the tubers stored in bodegas are nearly always for seed. It is common that the potatoes are placed in large piles separated by size and variety. Owing to the architecture of the bodegas, it is possible that some light will enter but this effect is neutralized by storing in heaps.

Figure 10. Three types of storage in Cuzco



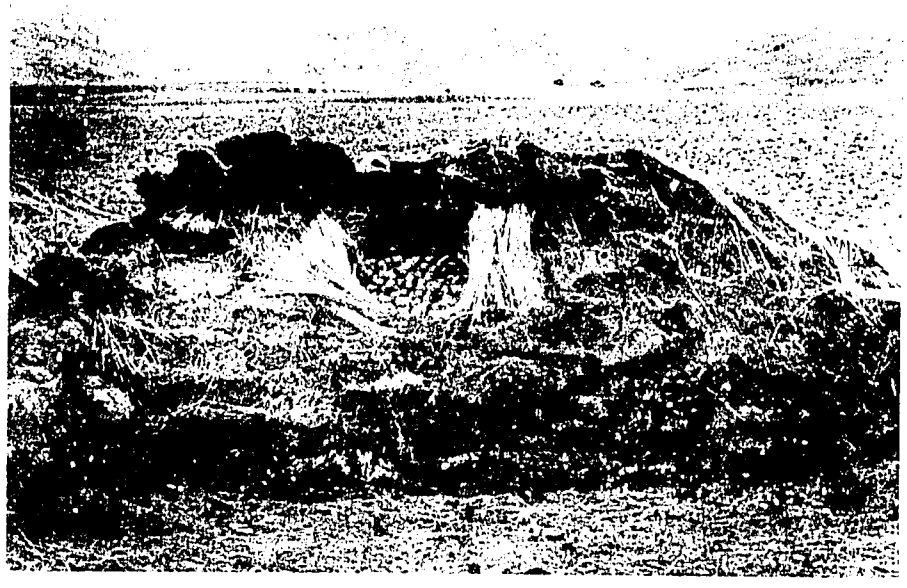


Photo 10. Traditional storage in the Puna of southern Peru. (O. Cuyubamba).

Photo 11. The pirhuas storage system of Cusco. (E. Schmidt).

3. Farmer Strategies and Perceptions of Storage: A Survey of Cusco

Schmidt (1984) interviewed 122 farmers in over 20 zones of the Department of Cusco in a study aimed at uncovering how farmers perceive their storage practices and problems. Of particular interest was the question of whether or not farmers store ware potatoes for speculative ends, as is common in developed potato producing countries. Numerous storage improvement projects in developing countries have been based on the assumption that the primary storage motivation of farmers is profit as a result of rising prices during periods of low supply. The following paragraph summarize her findings (see the original paper for details, Schmidt, 1984).

A differentiation between producers oriented toward the market and those that only produce for their own consumption can be made. Both types are found in Cusco, although the latter type predominates. In the subsistence strategy, one finds staggered sales para el gasto that does not necessarily imply that the producers are commercially oriented or profit seeking. They use their resources (potato, cereals, etc.) in such a way that permits them to obtain inputs or foods that are not produced by the domestic unit. Women play a leading role in small-scale storage and sale of the potato. Not all producers sell potatoes para el gasto but depending on what amounts of the different crops they have in store they might sell grains, animals, or other vegetables. Objectives of household storage (exchange for labor, barter, gifts, religious and social obligations, petty cash sale) are similar to those discovered by Egoavil in Palca (1985). Delayed sale for obtaining expense money or "petty cash" follows a strategy of distribution/storage of different agricultural products on which the domestic unit counts, playing a role like a domestic bank.

Storage amounts and strategies are constantly changing as farm households balance between needs and resources and technologies available to solve problems. The majority of small (and some medium size) farmers have a greater margin for marketing stored potatoes since they do not usually receive credit from the agrarian bank. Credit organizations press for an immediate repayment of loans, forcing sale at harvest time. Farmers with flexibility and who are commercially oriented follow market fluctuations closely and manage global information based on past experiences. They know, for example, than in September/October, potato has a good price. Farmers store in sacks, waiting for better prices. Some producers store potatoes by variety, eating varieties of short dormancy before those of long dormancy.

As in Palca (Egoavil, 1985), a high percentage (30%) sell the early harvest (muhuay) keeping only an indispensable minimum to tide over the household until the cosecha grande (main harvest). At the main harvest, all producers direct some of the harvest to the market in two ways: (1) sell directly at moment of selection or (2) stagger sale or delay sale until the month of September or October.

VI. Conclusions

Peru is characterized by a complex potato production pattern, and as such is an excellent case to illustrate the diversity of storage needs, which a complex system precipitates. Potato production in the two main agroecological zones --coast and highlands-- have marked seasons dependant on climate. These varying degrees of complexity make storage decisions difficult. In addition to the coastal-highland difference, there is also one major and one minor potato crop in the Peruvian highlands. As in many tropical countries considerable local variation exists as well. The harvest from coastal valleys occurs between the major and minor highland crops and helps guarantee that fresh potatoes are available in some parts of the country throughout the year.

In the highlands, traditional storage of potatoes dates back to the origins of agriculture thousands of years ago in contrast to the coast where potato cultivation is relatively new. On the coast, potatoes are planted during the coolest months of the year; in the highlands, where the larger portion is planted on dry land, planting is determined by the rainfall and frost cycles. However, the different planting seasons in the zones mentioned have a complementary character, allowing an almost continuous supply of potatoes to Lima --the main urban market-- during the entire year. However, problems sometimes occur in marketing during the months in which the major part of harvests takes place, as well as "periodic" scarcity of potatoes toward the end of the growing cycle in each of the production zones. Also, due to lack of good transport and trade links between many of the individual production areas, storage is required to maintain a continuous supply to consumers in regional markets. This storage requirement is largely satisfied at the individual farm level where small quantities of potatoes are stored for a range of home uses including future sale. Quantities stored in this way rarely exceed 10 tons but even assuming that only 75% of potato producing farms store 500 kg of potatoes for future sale this amounts to some 650,000 tons or around 40% of the national annual production.

1. Role of Varieties in Storage

The willingness to invest in improvements can be influenced by varieties. For example, modern higher yielding varieties are commonly stored at the farm for home consumption and future sale but principally as a means of maintaining cash-flow into the producing household. The locally preferred native varieties, for which there is commonly a strong demand, are stored for both home consumption and profit-making reasons. This practice also reflects the fact that because native varieties cannot be produced on the coast their price responds more directly to the local supply and demand situation. The prices of modern varieties, which can be grown throughout the country except at elevations above 4,000 m tend to reflect prices in the Lima or other large urban markets irrespective of the local supply/demand situation. This means that attempts to improve storage practices in Peru should primarily be aimed at the individual small-scale farm level. This complexity of the total market system coupled with the strong individualism of producers also explains many

attempts to introduce large scale community or government storage facilities have met with very limited success.

2. Seed Storage

The coast depends for its potato crop basically on highland seed. Only a small proportion of the area planted in potatoes is done with local seed produced on the coast, that is to say, seed tubers which are a first-year reproduction of highland seed, called criolla, which has some advantages as compared to the highland seed. Normally, this seed is stored during the months of highest temperatures on the coast in: (1) refrigerated stores, (2) in the highlands, (3) colcas on large scale (30 to 50 t), and (4) colcas on a small scale. Cold storage is the safest way of storage but accessible to only a few farmers. Rustic storage in the colca is practiced successfully by very few farmers due to risk of dehydration, rotting, and insects.

Seed tuber storage in the highlands is mainly done in in-house stores which may be rooms or bodegas, depending on the type of producer. The potato is placed in troqas or graneles depending on the amount to be stored. In order to protect the seed tubers from insects, aromatic plants are utilized like muña or eucalyptus. This is done more frequently among the small producers, commercial insecticides are used by the medium sized producers. The most evident problem to farmers is insect damage. The introduction of improved varieties and the growing market orientation has brought about alteration of traditional storage practices.

3. Storage for Home Consumption

Potato storage for home consumption on the coast is done among small producers, members of cooperatives, and agricultural laborers, with the objective to save their own supply of potatoes after the harvest. Amounts stored depend on family size but in general around 500 kilos per family are stored for a period of 2 to 4 months. Various rustic forms of storage have developed, as for example, to store potatoes in paper sacks, beneath sand, on cement floors, or covered with banana leaves.

In the highlands, extreme care is taken with storage for home consumption, since potatoes must last until the following harvest. The storage period varies with the cropping calendar. In the region of Cusco, the storage period can last eight months. The most common form of potato storage is: (1) corridors, attics (altillos), and (2) in rooms. In both cases, conditions of darkness are very important. Amounts stored are variable and depend on type of producer. The medium size family in the region of the central highlands stores between 500 and 1,000 kg. In the Cusco area, the ideal minimum amount is approximately 500 kg.

4. Storage for Future Sale

Potato storage for future sale on the coast is done in exceptional cases only, although some years present an oversupply in potatoes.

Delayed harvest is a way of delaying the introduction of new potato to the market but the need to honor bank credits, need of capital for the coming season and uncertainty of prices make this practice relatively rare.

In the highlands, although environmental conditions for long-term storage are considerably better than on the coast, the storage of potatoes for future sale is also rare. This is due to: (1) probability that no increase in price will occur which would cover the storage cost and the losses in weight and quality; (2) necessity to pay agricultural debts and or the need for capital at the time of the harvest. However, sporadic selling of stored table potatoes, in small quantities on the local markets is very widespread among the small producers of the highlands, as a mechanism to obtain some income in time of need (para el gasto).

In summary, the traditional storage of potatoes in Peru has complex characteristics. Technical and socioeconomic investigations to improve traditional storage conditions must acknowledge this complexity which involves a myriad of storage facilities and strategies ranging from the household level to the national level. Most attempts, however, to improve storage have concentrated on large-scale governmentally-controlled stores often located outside the main production areas to the neglect of household storage. This study has illustrated that in terms of volume and economic significance local level storage is vastly more important. In the future, the technical needs of farm household storage should be directly addressed by programs.

Photo 12. Marketing small amounts of stored potato in Pisac, Cusco. (R. Rhoades).

References

Antúnez de Mayolo, S. 1981. La Nutrición en el Antiguo Perú. Banco Central de Reserva del Perú. Oficina Numismática. Lima, Perú.

Auroi, C. and P. Vilca. 1985. Eficiencia Técnica y Económica de la Producción de Semilla de Papa en la Sierra Central del Perú. Documento de Trabajo 1985-2. Ciencias Sociales, Centro Internacional de la Papa, Lima, Perú.

Baker, P. 1962. The application of ecological theory to anthropology. In: American Anthropologist. Vol. 64, No. 1, February.

Benavides, M. and J. Recharte. 1981. Informe Preliminar sobre el Almacenamiento Tradicional de la Papa en el Perú. Manuscript.

Booth, R.H., R.L. Shaw and L.J. Harmsworth. Almacenamiento de papa para países en desarrollo. Lima. Centro Internacional de la Papa, Lima, Perú.

Booth, R. and G. Burton. 1983. Future needs in potato post-harvest technology in developing countries. Agriculture, Ecosystems and Environment (9) 269-280.

D'Altroy, T.N. and T.K. Earle. 1985. Staple Finance, Wealth Finance and Storage in the Inka Political Economy. Current Anthropology 26(2): 187- 197.

D'Altroy, T. and C. Harstorf. 1984. The Distribution and Contents of Inca State Storehouses in the Xauxa Region of Peru. American Antiquity 49(2). 334-349.

Egoavil, M. 1985. Tecnología productiva y almacenamiento de papa en la unidad campesina: Palca, Perú. Universidad Nacional Mayor de San Marcos, Lima, Perú.

Fano, H. 1986. Personal communica ...

FAO. 1981. Food loss production in perishable crops. FAO Agricultural Services. Bulletin 43. Food and Agriculture Orgnization, Rome.

_____. 1985. FAO Basic Data Unit. Primary Data. Rome, Italy.

Fernández, A. 1976. Infraestructura para la comercialización del producto alimenticio papa. Lima, EPSA.

Flores Saenz, O. 1980. Política de abastecimiento de alimentos y cambio tecnológico: el caso de la papa en el Perú. Lima, IICA.

Franco, E., D. Horton, F. Tardieu. 1979. Producción y utilización de la papa en el Valle del Mantaro, Perú. Resultados de una encuesta agroeconómica de visita única. Documento de Trabajo 1979-1. Centro Internacional de la Papa, Lima, Perú. 121p.

Franco, E., C. Moreno and J. Alarcón. 1983. Producción y utilización de la papa en la región del Cuzco; Resultados de una encuesta de visita única. Documento de Trabajo 1983-2. Centro Internacional de la Papa, Lima, Perú. 103p.

Girón, G. 1976. Estudio básico de la producción de papa en el Perú. Lima, (borrador).

Graber, E. 1974. Oferta, demanda y comercialización de la papa en la Región Central.

Horton, D. 1983. Potato Farming in the Andes: Some Lessons from On-farm Research in Peru's Mantaro Valley. Agricultural Systems 12:171-184.

Manzaneda, V. 1984. Estructura y eficiencia económica de la comercialización de papa consumo en el Perú. Tesis. M.Sc. UNA, La Molina. (draft).

Mayer, E. 1981. Uso de la tierra en los Andes: Ecología y agricultura en el Valle del Mantaro del Perú con referencia especial a la papa. Lima, Centro Internacional de la Papa. 127p.

Maxwell, S. 1982. Harvest and post-harvest issues in farming systems research. Bulletin Institute of Development Studies, Sussex. Vol. 13(3): 21-31.

Ministerio de Agricultura, Oficina Sectorial de Estadísticas de Producción Agropecuaria. 1981. Lima, Perú.

Ministerio de Agricultura. Estadísticas Agrarias. Lima, Oficina Sectorial de Estadísticas.

Ministerio de Agricultura y Alimentación. n.d. Programa de abastecimiento 1980. Producto Papa. Dirección General de Comercialización. Oficina de Programación.

Noonan, G. Control for planning food security. Ceres No. 95, Vol. 16. No. 5. Set-Oct., 1983.

Oficina Nacional de Estadísticas y Censos (ONEC). II Censo Agropecuario 1972. Lima, ONEC.

Oficina Nacional de Evaluación de Recursos Naturales (ONERN). 1970. Inventario, evaluación y uso racional de los recursos naturales de la costa, Cuenca del río Cañete. Lima, ONERN.

Prain, G. (n.d.). Informal Seed Systems in the Peruvian Central Highlands. Potatoes in Food Systems. Lima. Social Science Department, International Potato Center (in preparation).

Prain, G. and F. Uribe. 1986. El Conocimiento Campesino en la Cosecha, Selección y Clasificación de Papa. Minka 20. Huancayo, Peru.

Ravines, R. 1978, Almacenamiento y alimentación. En: Tecnología Andina. Lima, Instituto de Estudios Peruanos.

Rhoades, R. 1981. Farmer acceptance of new technology: A proposed research project. Report of the Second Social Science Planning Conference "Social Science Research at the International Potato Center." Held at the International Potato Center September 7-11, 1981. pp.147-150.

Rhoades, R. and R. Booth. 1982. Farmer-back-to-farmer: A model for generating acceptable agricultural technology. Agricultural Administration 11, 127-137.

Rhoades, R. and M. Benavides. 1980. Recommendations for on-farm agroeconomic trials: Cañete 1980. Lima, Centro Internacional de la Papa.

Rhoades, R. 1986. Changing a Post-Harvest System: Impact of Diffused Light Potato Stores in Sri Lanka. Agricultural Systems 19: 1-19.

Schmidt, E. (n.d.). Estrategias tradicionales de almacenamiento de papa autoconsumo en el Departamento de Cusco. Documento de Trabajo. Ciencias Sociales (en prensa).

Schmidt, E., O. Cuyubamba, R. Rhoades, and R. Booth. 1985. A Case Study of the Generation, Transfer, and Adoption of the Diffused Light Technology for Storing Seed Potato Tubers in Peru. Impact Report prepared for IDRC. Manuscript.

Scott, G. 1981. Potato production and marketing in Central Peru. Ph.D. thesis University of Wisconsin-Madison.

Shaw, R. and R. Booth. 1980. Introducción al almacenamiento de papa. Lima, Centro Internacional de la Papa.

Troll, C. 1968. The Cordilleras of Tropical Americas. Aspects of climatic phytogeographical and Agrarian Ecology. In: Geoecology of the mountainous regions of the Tropical Americas. Carl Troll (ed.).

Tupac Yupanqui, A. 1978. Aspectos fisiológicos del almacenamiento de tubérculo-semilla de papa: Influencia de la luz y temperatura. M.Sc. thesis, Universidad Nacional Agraria, Lima.

Tupac Yupanqui, A. 1981. Almacenamiento de papas en condiciones ambientales en Huancayo, Lima, Centro Internacional de la Papa.

Werge, R. 1977. Potato storage systems in the Mantaro Valley. Lima, Centro Internacional de la Papa.

_____, 1979. Potato Processing in the Central Highlands of Peru. Ecology of Food and Nutrition. 7:229-234.