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Improvement of Postharvest Grain Systems

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POST-PRODUCTION SYSTEMS FOR BASIC GRAINS IN THE WESTERN HIGHLANDS OF GUATEMALA: A DESCRIPTION AND EVALUATION

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REPORT SUMMARY

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SUMMARY STATEMENT

This mission was undertaken as an adjunct to the work of the Small Farmer Diversification Project, Region I, Guatemala. The team visited different ecological zones of Region I (Altiplano) with Dirección General de Servicios Agrícola (DIGESA) personnel. The objectives of the visits were to experience the conditions, interview farmers about their post-production practices for basic grains, and take measurements of the parameters which affect grain handling and storage. Evaluations and recommendations were prepared for use by USAID/Guatemala, the Equipo de Asistencia Técnica (EAT) of the Small Farmer Diversification Project, Instituto de Ciencias y Tecnología Agrícola (ICTA), and DIGESA personnel. Major findings and recommendations follow: (1) Maize storage at altitudes above 7,200 ft (2,200 m), as well as grain legume storage throughout the Altiplano is being handled very successfully with current technologies. Unless pre-storage practices change significantly no further investigation is needed. (2) Maize storage at lower altitudes is variable and not uniformly successful. The team recommended that the economics of storage in sealed metal barrels be investigated where losses in maize storage are evident. (3) A package of sanitation and cultural practices was recommended to provide an integrated approach to pest control for maize stored at the lower altitudes, below 7,200 ft (2,200 m). (4) The team recommended research into certain in-field practices used for wheat. (Wheat is the cash crop of most farms in the Altiplano, and is not stored on the farm.) The research should answer questions about the level of loss incurred at these steps and whether the loss is being recovered by gleaners.

A short course was presented for DIGESA, ICTA, and Instituto Nacional de Comercialización Agrícola (INDECA) personnel September 18-21, 1984, at the Centro de Capacitación in Quezaltenango, Guatemala. Thirty-three participants attended the course, which covered the basics of grain storage as well as the adaptation of pest control practices to the small farms of the Altiplano. Slides taken during the farm visit were used in the instruction. Groups of participants developed and made presentations covering storage characteristics in their areas, appropriate pest control techniques, appropriate drying techniques, advantages and disadvantages of various storage structures, and the economics of various forms of storage.

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UNITED STATES DEPARTMENT OF STATE

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Improvement of Postharvest Grain Systems

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ACRONYMS AND GLOSSARY

EAT	Equipo de Asistencia Técnica - Team of specialists providing planning and technical assistance to the Small Farmer Diversification Project
DIGESA	Dirección General de Servicios Agrícolas - Crop production extension system - Government of Guatemala
ICTA	Instituto de Ciencias y Tecnología Agrícola - Agricultural research agency - Government of Guatemala
INDECA	Instituto Nacional de Comercialización Agrícola - Government grain price stabilization agency, buys, stores, and sells basic grains
USAID	United States Agency for International Development
Altiplano	High plain. Relatively flat area at high altitudes.
Apartado	Pre-storage selection process in which less storable ears are set apart from more storable ears
Aporrear or Aporreado	Threshing by beating with sticks, flails, shovels, etc.
b.h.	Base húmeda (wet basis)
Cajón	Large wooden box used for grain storage. Entire top opens. Usually raised on wood or concrete blocks
Ejotes	Green beans used as vegetables
Elote	Roasting ears, field corn at milk to dough stage used as vegetable
Era	Circular or conical stacks of wheat sheaves
Gabilla	A sheaf of wheat bound with straw or string
Galera	Wooden structure, usually with wooden floor and semi-enclosed sides. Used as a general warehouse as well as grain store
Hoz	Small sickle held with one hand
Manguerna	Groups of maize ears with husks tied together

Manojo	Handful, used to indicate a small group of harvested wheat plants tied together
Mecapal	Band of leather or woven fabric, placed on forehead and fastened to loads carried on one's back
Paja	Straw of some cultivated or wild grass
Picholero or picholear	Gleaner, to glean
Q	Quetzal = Q1 = US$1
qq	Quintal, 100 pounds
Red	A net made to carry produce on one's back or to transport other bulky cargo like maize ears, large vegetables, baskets, etc.
Tapanco	Space between ceiling and roof where ear maize and rarely used articles are stored. Floor is usually solid.
Tonel	Metal drum, usually 55 gallon size. Usually with bung, not open top
Troja	Crib-like structure usually apart from living area. Has its own roof. Sides are usually solid and of varying heights. Floor usually elevated about 1 m
w.b.	Wet basis

BACKGROUND

The Guatemala Altiplano is a densely-populated, mountainous region located in the northwest part of the country. It is the ancestral homeland of various Mayan-related indigenous groups whose descendants now form the bulk of the rural agricultural population.

Farm sizes are small. Over 50 percent of all Guatemalan farms--representing more than 80 percent of the rural population--are smaller than 1.4 ha. In the Altiplano, the centuries-old custom of dividing land between offspring has reduced many farms to less than that necessary to feed the average size family. Extremely steep slopes have been brought into production and are intensively farmed.

Farm incomes are low. According to a 1982 estimate, 90 percent of the families in the Altiplano have incomes of less than US$480/year. More than half realize yearly incomes of less than US$250. Income is generated through the sale of wheat, handicrafts, or fruits and vegetables. Many males leave their farms after planting to sell their labor in the Southern Coast, where coffee, sugar, bananas, and other cash crops require seasonal labor. They return for the harvest, land preparation, and sowing of the next year's crop.

Maize and beans are produced mostly for on-farm consumption. Maize is the basis of the traditional diet, providing most of the calories. A daily average of from one to one and a half pounds is consumed per person. Dry beans provide an important source of protein. Wheat is a cash crop. Little is consumed on the farms where it is produced.

Basic grains mature slowly in the cool, cloudy atmosphere of the Altiplano. Maize and beans are typically planted sometime before the onset of the wet season (March-May) and do not mature until just before the dry season (October-

December). Wheat is sown between April and June, and is harvested between October and January. The multitude of microclimates in the Altiplano is the reason for the range of planting and harvesting dates.

Maize is usually consumed in the form of tortillas. After being shelled and washed, it is boiled for several hours with lime. After cooling overnight, it is rinsed and wet-milled, usually by a neighborhood custom miller. It may be milled again with a stone mortar and pestle before being formed into tortillas and cooked on a dry griddle.

The Small Farmer Diversification Project was developed to assist the Altiplano farmers make maximum use of their meager land resources. The project has several components, which include research into existing production and post-production practices, investigation of various mixes of cropping and animal production patterns that extract the maximum output per unit of input, and the establishment of credit facilities. This trip was conducted as part of the review of current post-production practices.

DESCRIPTION OF THE POST-PRODUCTION SYSTEMS FOR BASIC GRAINS AND GRAIN LEGUMES

Maize

Pre-Harvest Drying

Typically, maize is allowed to dry on the plant about six weeks after it is physiologically mature. (This estimate was made by subtracting two weeks from the reported period between the end of the elote season and the harvest.) During this time it may be bent over if birds begin to cause major damage. More commonly, however, the plants are left upright during this pre-harvest drying period.

The foliage is usually removed shortly after the grain is mature (leaves below the ears may already have been removed) and used for animal feed. This leaves the naked stalk and ears exposed to sun and drying air. Where maize stalks are used as support for bean plants the maize harvest must await the bean harvest. In those few places where pasture is abundant, ears and aerial plant parts may be left as is until harvest.

Harvest

In certain cases, maize harvest consists of cutting the plants at ground level and stacking them where they will be carried to the house area by either human or animal power. Ears are then removed from the plants at the house area.

A more common method is the following: ears are removed from the plant by hand. If criollo varieties are used, this requires that the harvester bend the stalk over, as the ears may be 6-8 ft (1.8-2.4 m) from ground level. Ears are then thrown to a center point in the field (amontonado), or placed in sacks or baskets to be transported to some in-field collection point.

On-Farm Transport

If maize is harvested as ears (rather than as an entire plant), it is almost always loaded into carrying nets (redes). It is then transported to the house area on the back of a worker, who uses a mecapal to secure the net to his head, or the net is tied to horses.

Selection

A very important pre-storage practice is the apartado, or selection of the more storable ears. Less storable ears are small ones, or those damaged by field fungi, or in some cases may be those whose husks have been damaged by birds or insects, leaving the tip of the ear exposed. This selection may take place at the moment of harvest--in which case the harvester marks the less storable ears by removing the husk from them--or it may be done at the house area. In either case, ears perceived to be higher storage risks are set apart (apartado), to be used first in animal feeding or food preparation. On some farms the ears thus selected are physically removed from the more storable ears. In other cases, the two are stored together, with the less storable ears being marked by having the husks removed.

Sometimes, maize perceived to be too badly damaged for human consumption is shelled immediately after the post-harvest drying period and set aside for animal feed. This grain will not usually be placed in store, but will be left in some easily-accessible place.

Post-Harvest Drying

Once inside the compound or at the house area, maize ears are typically left to dry in the sun. It appears to be somewhat more common to dry husked maize than to dry ears with the husk.

Several methods of post-harvest drying are typical in the Altiplano. Ears may be placed directly on the soil, or a mat of paja or pine needles may be

prepared, and the ears placed over the mat. Ostensibly, the mat serves to keep the maize clean and to avoid moisture from the soil moving into the drying maize.

Ears are also dried on cement patios, if available, or on metal or tile roofs. Some producers report using tapancos for drying before maize is stored in cajones.

The amount of importance given to this step appears to be extremely variable among maize producers. Some producers leave ears drying up to one month. Others evidently place maize in storage directly from the field.

Shelling

Most maize appears to be shelled every day, or every other day as needed. Some producers, however, shell large quantities at one time, and may aporrear, rather than hand shell. This is usually accomplished by placing a few ears inside sacks or redes, then beating with sticks or shovels.

Storage

There are five types of storage structures commonly used in the Altiplano. There is some tendency for the type of maize storage to vary by altitude. Tapancos, for either husked or unhusked ears, are used extensively at higher altitudes, above 8,800 ft (2,600 m). Maize stored in cajones is also commonly observed at those altitudes. Cajones are mainly used for ear maize but occasionally are used for shelled maize.

At middle altitudes, between 8,500 ft (2,600 m) and 7,200 ft (2,200 m), tapancos and cajones appear to be utilized equally often, either for husked or unhusked ear maize. Storage of shelled maize appears to be somewhat more common at middle than at higher altitudes. Trojas are sometimes used for the storage of ear maize at all altitudes.

Throughout the higher and middle altitudes, seed corn is often hung from the ceiling, in groups of ears called manguernas. Husks of two ears are pulled back from the grain, but are not removed. These husks are tied together and then groups of such pairs are made into bundles. The seed ears are selected based on size, color, straightness of the rows, and luster of the seed. The middle half of the ear is used for seed.

At lower altitudes, maize post-production practices--including storage--appear to be more variable than at the higher altitudes. Tapancos, cajones, trojas, galeras, and toneles appear to be commonly used. Except in toneles, either husked or unhusked ear corn may be observed. Twenty-quintal metal silos, provided by INDECA, were observed at one location but are considered to be infrequently used by farmers.

Marketing

Although only a small portion of the maize produced in the Altiplano is marketed (the Quezaltenango INDECA terminal purchased only 78 qq of local maize, for example, in 1983) there are farmers who produce more than they consume. The strategy of these farmers, as reported by them, is to hold their maize until June, just before the Southern Coast's production reaches the market.

There are other cases when maize is sold because of economic necessity. This appears to be common in the Altiplano, and results in a majority of the marketed maize being sold at harvest (November-January).

In either case, the producer contracts a trucker (usually local) to transport his maize. (Merchant-truckers seem to be the exception rather than the rule.) The trucker provides no service other than transport, and receives payment when the grain is sold at a major population center. Transport cost reported to the team varied from Q0.15/qq to Q0.55/qq depending on distance and road conditions.

Grain Legumes - *Phaseolus* Beans

Many types of *Phaseolus* spp. are produced in the Altiplano. Black, red, white, and multicolor beans were observed either in monoculture or in multiculture with maize. Multicultures of maize, beans, broad beans, and squash were also observed in various combinations.

Multiculture/In-Field Drying

The in-field drying period (between physiological maturity and harvest) is typically very short since the pods of many genetic lines of beans begin to open as they dry. Some producers, however, report leaving the pods on the plant until they are ready to thresh.

Multiculture/Harvest and Transport

In multiculture, bean harvest consists of picking the pods, which are collected in baskets and carried to the house areas. The pods that mature first are often harvested green, to be used as *ejotes*, leaving the slower-maturing pods of each plant to be harvested as dry beans. If the entire production is to be harvested as dry beans, two harvests of the same field are often accomplished, since different pods of the same plant may have widely different maturity dates.

Multiculture/Post-Harvest Drying

Harvested pods are typically transported to an area where they can be spread to dry over metal or concrete. They are often placed on metal roofs. Drying may take one week or more. The pods are moved to a sheltered area when rain threatens.

Multiculture/Threshing and Cleaning

After the bean pods are black and very dry, they are threshed *aporreado* by beating with sticks over a hard surface (cement, hard ground, etc.). The resulting mixture of seeds, plant trash, and dirt may be stored as is or cleaned by winnowing, sieving, or both.

Multiculture/Storage

Se Monoculture/Storage below.

Monoculture/In-Field Drying

The pre-harvest drying of beans produced in a monoculture is usually short. As soon as most of the pods are filled, harvest begins. This practice prevents the earlier-maturing pods from opening as they become drier.

Monoculture/Harvest and Post-Harvest Drying

When beans are produced in monoculture, harvest consists of pulling the entire plant from the ground. They are then left on plant stubble, weeds, stumps, etc., where they will not be in direct contact with the soil. The plants may be left in the field for several days (usually 6-15), or may be transported immediately to some sheltered area.

Monoculture/On-Farm Transport and Threshing

Bunches of bean plants are fastened together in bundles and carried to the threshing area which is usually located near the house. Threshing is accomplished aporreado as with the multiculture beans above. The difference is that the whole plant, not just the pods, is subjected to the process. This results in a larger amount of plant trash being present in the threshed mixture. The threshed beans may be cleaned or may be stored with the plant trash.

Drying of Threshed Beans

In contrast to the common practice in much of Central America, no evidence was found that threshed beans were sun-dried before storage.

Storage

The most common method for storing beans throughout Region I appears to be in sacks. The sacks are usually placed inside the house and are commonly found inside cajones or trojas. It is also fairly common to store beans in large covered earthen jars or woven wooden baskets.

Marketing

Except for the Huehuetenango area, little of the bean production of the Altiplano is marketed. In fact, most small farmers cannot produce enough to meet their yearly consumption requirements. A few months after the harvest the typical family's dry bean supply is exhausted, and the family must either purchase beans or do without.

Those who are able to produce excess beans report that storage for later sale is profitable. At the higher altitudes, market prices are reported to reach their peak in October and November.

Grain Legumes - Broad Beans

These legumes are often found in the Altiplano region, but evidently are not often produced in sufficient quantities to allow for year-long storage. They appear to be found in many small and most larger markets, however, as dry beans.

The lowest pods are often used as vegetables. When mature, the rest of the pods are picked, transported to a drying area, threshed and stored, most often in bags. The bags may be placed in the house or in trojas or cajones.

Wheat and Other Small Grains

Pre-Harvest Drying

In lower areas, where two wheat crops are possible yearly, the pre-harvest drying period is very short. Harvest occurs when the youngest grains are only partially mature. In areas where wheat is produced once a year the harvest coincides with the beginning of the dry season. The pre-harvest drying in this case is reported to be somewhat longer, perhaps lasting up to two weeks.

Harvest

Manojos, that is handfuls, of plants are grasped and cut at about 6-8 in (15-20 cm) above the ground with gentle pulling motion of the sickle (hoz). One of the plants is used to tie the rest together.

Post-Harvest Drying and On-Farm Transport

The manojos are laid to dry individually on the plant stubble, heads slightly downward. They may be left in this position for as long as two weeks, depending on the producer's custom and his perception of the ideal threshing moisture.

Several manojos are then formed into sheaves (gabillas), which are transported either by human or animal power to the threshing area. At the threshing area, gabillas are typically stacked in eras to await the thresher.

Poor and/or landless are allowed to glean (picholear) the fields. The long tradition of the picholeros seems to be an accepted part of the unofficial social security system.

Threshing

In the Altiplano, most wheat is now mechanically threshed. Several farmers transport their wheat to a central point accessible to the small, tractor-powered threshing machine.

The machines are typically of the hand-fed, spike-tooth cylinder type. The capacity of these machines is estimated to be 40 qq/day.

If mechanical threshers are not used, a round wooden threshing floor is constructed. Unthreshed wheat is placed on the floor and animals are driven over the plants. The resulting mixture of grain and plant trash is then sieved and winnowed.

Transport and Marketing

Most wheat is marketed shortly after threshing and is transported to the mills--usually located in major population centers--by contracted carriers. In certain areas, intermediates, or merchant truckers, purchase wheat at the farm gate, but this appears to be the exception rather than the rule. The producer normally travels with his wheat to receive payment at the mill and to pay the transport charges.

Wheat is the cash crop of most of those Altiplano farmers who, because of lack of infrastructure, cannot market fruits or vegetables. To provide a stable and profitable internal market, certain government and semi-autonomous organizations agree to fixed prices and marketing schemes. The wheat price is fixed for a one-year period (this year's official price is Q0.14/lb, the equivalent of $8.40/bu). Each mill receives a quota of the anticipated national production which it must purchase or forfeit its right to purchase imported wheat. (Guatemala produces less than half of its needs.)

Storage

There is no incentive to store wheat since prices do not vary over time. Therefore little more than seed wheat is typically kept on the farm. The seed storage period is short (3-5 months), but unused seed may be kept and utilized occasionally, throughout the remainder of the year.

Wheat is usually stored in bags. The bags may be placed in cajones or trojas, but may also be found stored on the floor of the living space.

EVALUATION OF POST-PRODUCTION PRACTICES FOR BASIC GRAINS

Maize

Pre-Harvest Drying

In many parts of Central America maize is left to dry in the field much longer than in the Altiplano. The reason for the short on-plant drying period may have to do with reducing losses to rodents, birds and/or insects.

The explanation heard by the team, however, has to do with soil water conservation practices. It may be that maize is harvested while still quite wet so that the ground can be worked early in the dry season. Thus, theoretically, a layer of worked soil is present to protect against excessive evaporation of ground water throughout the dry season. By conserving soil moisture in this way, maize can be planted and begin growing before the rain starts. This, in turn, allows for a longer growing season in the cool, wet highlands and ultimately increases yields. Whatever the reason, maize appears to be harvested while quite wet, so further drying is always necessary.

In the process of diversification, the pre-harvest drying period may be further reduced so that irrigated vegetable crops can be produced on the same ground. If this is contemplated, researchers must be careful that maize is not harvested so wet that it cannot be dried before mold damage occurs.

Harvest and On-Farm Transport

Harvest methods are typical of Central America and are well adapted in most areas visited. In certain flat areas, however, the team considered that the harvest was unnecessarily labor-intensive. A simple, small cart fitted with one tall side as a backboard and pulled by the available animal power could be devised. This could better utilize manpower by making the harvest more rapid and eliminating some of the drudgery.

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Post-Harvest Drying

Both the methods employed and the importance given to this component of the post-production system seem to vary significantly among producers. Despite the average high moisture contents, there was evidence that grain could be dried to below 15 percent (w.b.), even at higher altitudes. Lower moisture content maize was observed at one location. At another location at 8,500 ft (2,600 m), the temperature of air just above a concrete patio was measured at 82°F (27.8°C) at 10:30 a.m. The relative humditiy was 55 percent. This air could be used to dry maize to approximately 11 percent moisture content (w.b.). At another site, at about 6,600 ft (2,000 m) mid-morning temperatures measured on a metal roof and on black plastic placed on the soil were about 100°F (38.0°C). The relative humidity was low and the air could have dried maize to less than 10 percent moisture content (w.b.). These favorable drying conditions are present only a few hours per day, but could probably be utilized to reduce the moisture content to 13-14 percent (w.b.). Drier grain would facilitate successful storage, especially at lower altitudes.

Threshing

The hand-shelling of maize has a beneficial and extremely important effect within the typical post-production system in the Altiplano. Maize is being successfully stored at moisture contents considerably higher than those recommended for safe storage. One of the factors that make this possible is that the typical hand-shelling methods are gentle. The protective layers of the seeds are not damaged in the traditional handling and shelling processes, so the seed is more resistant to fungal invasion than it would be if it were mechanically harvested and shelled.

Any change in the farming system which encourages mechanical, or even apo-rreado shelling may tend to result in higher storage losses. This is especially

true in the higher and middle altitudes, where drying is more difficult and average relative humdities are higher. In the lower areas, if the moisture content is reduced to 13-14 percent (w.b.) before mechanical or aporreado threshing, little damage will result.

Storage

Throughout the Altiplano the team observed stored maize in excellent condition. After 9-10 months of storage the germination percentages tested were in the high 80 to low 90 percent range. The samples tested showed low (less than 10 percent) storage mold invasion and high levels of field fungi. All are indicators of good storage conditions.

Temperatures of grain stored in tapancos and cajones generally were in the 50-60°F (10-16°C) range at higher and middle altitudes. These temperatures were usually several degrees lower than ambient temperatures at the time of the visit (between 10:00 a.m. and 3:00 p.m.). Cajones located inside houses were especially cool. These cool temperatures were considered to be the second major reason why maize was in good condition despite its high moisture content.

Inside storage structures, relative humidities averaged about 68 percent. Inside cajones, the average relative humidity was 4 percent lower.

The moisture content of maize stored at the middle and higher altitudes usually ranged between 15.0 and 17.0 percent (w.b.). In one such site, however, samples taken at two farms measured 14.7 percent and 13.5 percent (w.b.). All moisture measurements were taken with a battery-powered Dickey-john meter with automatic temperature compensation.

Low levels of moth (tentatively identified as the rice moth, Corcyra cephalonica) infestation were often observed in maize stored at middle and high altitudes. The larvae tended to be found in grains already damaged by field fungi. Trogoderma beetles were also common in maize and fine material.

At lower altitudes grain weevils (Sitophilus spp.), greater grain borers (Prostephanus truncatus), bamboo powderpost beetles (Dinoderus minutus) and squareneck grain beetles (Cathartus quadricollis) were found in and about maize stores. Fungus-feeding insects, mites, and psocids were also observed.

The only example of serious insect problems was observed at a site in a lower, warmer area. There unhusked maize had been left in an open galera. All ears were severely infested with Angoumois grain moth (Sitotroga cerealella). Sitophilus weevils and squareneck grain beetles were also present. The approximately 4 m^3 of maize left at the time of the visit was estimated to be 70-80 percent damaged, causing a dry weight loss of approximately 15-20 percent.

The maize was being shelled daily for food, all of which was contaminated with larvae, cast skins, and fecal material. This case was probably not characteristic of the region.

At approximately the same altitude, maize in metal barrels (toneles) was observed. The toneles were located under a roof in constant shade. The grain temperature measured 60°F (15.6°C) and the moisture content was 14.7 percent. There was no evidence of any type of damage or loss after 10 months of storage.

Evidence of mice activity was observed in all tapancos visited, as well as in most galeras and trojas. No evidence of mice damage was observed in cajones. (Rats seem to be rare in the Altiplano.)

The cajones seen were, in general, tight-fitting and strongly-constructed. All the cajones observed by the team had been placed on wooden or concrete blocks which raised them 4-8 inches (10-20 cm) above the dirt floors. Some had been patched with sheet metal where mice had gnawed holes.

Cajones appear to be used as shelves and general storage areas. Unfortunately, dangerous pesticides are often observed on top of cajones where maize is being stored. This, of course, is an undesirable practice because of the possibilities of contaminating the stored food.

Marketing

Producers report that in some years, the price of maize may increase Q3-4/qq over harvest price. In general, however, the price differential over time appears to be minimal, and the return to storage rather insignificant. Diversification efforts will probably have little effect on maize marketing. The team noted that prices being offered to farmers in the Altiplano were only 2-3 centavos less than the retail price in Guatemala City. This small margin would seem to indicate a reasonable and efficient marketing system.

Grain Legumes

The team was unable to observe bean harvesting, although post-harvest drying was observed on several occasions. Phaseoleus beans in the central market in Guatemala City were moderately infested with bean weevils, but in the Altiplano all beans observed--both in the markets and on farms--were sound. There were no hardshell problems reported.

Wheat

Post-Harvest Drying

The practice of drying manojos several days before transporting them may permit shattering (grains falling out of the head) to occur. The presence and severity of the loss will depend on varietal characteristics and ambient conditions. Whether individual grains (as opposed to entire heads) are recovered by gleaners is not clear.

Drying and Storage After Threshing

Drying of threshed wheat does not seem to be practiced. Millers report that the majority of local wheat is delivered at between 18 and 20 percent moisture (w.b.). Some is delivered at up to 24 percent (w.b.).

Not even seed wheat kept on the farm appears to be dried. Although most leftover wheat appeared to be in reasonably good condition, some was obviously moldy. Germination was in the 60 to 80 percent range and samples tested were about 20 percent infested with storage molds, mostly *Aspergillus glaucus*. In one farm cracked wheat was infested with several types of insects. This was providing a source of infestation of the new crop maize being stored nearby.

Marketing

In addition to fixing prices and quotas for wheat buyers, the government regulatory agencies evidently establish certain buying practices. Millers report that no price discount may be levied for poor quality local wheat. The weight of water in excess of 16 percent moisture (w.b.) is subtracted from the delivered weight.

The result of this governmental policy, combined with the thresher's payment scheme, is to remove all economic incentive to deliver clean, dry and sound wheat to the mill. The thresher's charges are based on the weight of the output, rather than input, so he has no incentive to reduce the amount of impurities in the threshed product. (This may, however, provide an incentive to reduce unthreshed grain losses since these losses may reduce the amount of threshed grain--and therefore the thresher's income for a given amount of threshing time.)

RECOMMENDATIONS AND PROMISING AREAS OF FURTHER RESEARCH

Maize

Good Storage Practices

Whenever maize storage in tapancos, cajones, galeras, or trojas is discussed in relation to problems and losses, the following package of techniques should be recommended. (This package was developed in large part by DIGESA personnel during the short course.)

A. Good Sanitation - The storage structure should be cleaned prior to adding the new crop. Trash and infested grain should be removed and buried or burned. Sacks should be washed with detergent and sun-dried before using with new crop corn. Structures may be disinfested with Malathion or another approved insecticide if this can be accomplished without contaminating living areas.

B. Selection and Separation - Long, tight-fitting husks should not be totally removed. A few layers should be left to protect against insect infestation and mold. Infested ears, or those having damaged husks should be physically separated from the sound ears. At lower altitudes, these should be removed to another structure or room to avoid cross-infestation.

C. Rapid Drying - Ears should be placed on roofs, patios, or on plastic (black if possible) where there is maximum exposure to wind. They should not be placed directly on the soil, where soil water re-wets them during cool hours. More rapid drying will reduce the chance of spoilage.

D. Maintain Cool Temperatures - Cajones should be placed inside the house if possible. All storage structures should be located where they will be constantly shaded.

E. Special Case - If severe infestation is already underway, especially in husked ear maize, recommend the following: first, further drying if

possible. Second, since the most likely cause of the damage is the *Sitotroga* moth, which reproduces more successfully in ear than bulk maize, shell the maize. Third, place the shelled grain in sealed barrels, if available. If not, a tight *cajón* would be the second choice. Fourth, fumigate if physically and economically feasible.

High Altitude Storage

Maize is being stored well at high (above 8,500 ft, 2,600 m) and middle (between 8,500 ft and 7,200 ft, 2,600 m and 2,200 m) altitudes. It need not be investigated further unless a major change in the system occurs. If, for example, there is an increase in the incidence of mechanical shelling, more drying would likely be required to assure successful storage.

Lower Altitude Storage

Below 7,200 ft (2,200 m) significant storage problems were noted. There appears to be room for investigation and extension of the best techniques.

One solution commonly used throughout inland Central America and observed in the Altiplano, is hermetic storage in metal barrels. Maize is dried on the ear to less than 15 percent moisture (w.b.), threshed, cleaned, and loaded into clean barrels. Loading is done during early morning hours when the grain is cool but has no condensation moisture. Compaction is accomplished by shaking the barrels periodically during loading and by filling to capacity. The barrels are sealed and placed in constant shade. The respiration of molds quickly removes the oxygen, so mold and insect growth ceases.

Whether storage in barrels is economical depends on their cost and the level of loss in alternate storage structures. If, as reported, barrels cost Q10.00 each, they would pay for themselves in 5 years only if they reduce losses by 7 percent. This figure is based on 26 qq of stored maize at Q8.00/qq. Seven barrels of 4 qq capacity are needed at Q10.00/barrel = Q70.00. The

equivalent quantity of maize at Q8.00/qq = 8.75 qq. Thus 8.75 qq of maize would have to be saved over a 5 year period to repay the investment in the barrels. The loss per year that would have to be eliminated in order to save 8.75 qq in five years is about 7 percent, since (0.067) (26 qq/yr) (5 years) = 8.75 qq maize. Painted, well maintained barrels are known to serve for more than 30 years. Using proper techniques, storage losses are negligible.

Efficient Harvesting Techniques

In much of the Altiplano, maize is produced in small plots on steep terrain. For these areas the current harvesting and transport techniques are adequate.

Where large extensions of maize are produced on flat ground with the help of animal power, the excessive use of human power in harvesting and transport appears to be more a matter of tradition than appropriate technology.

In these areas, the team recommends that the following method be introduced on an experimental basis to eliminate double handling and reduce the drudgery of harvest. First, the traditional cart is fitted with one high (1.5-2.0 m) sideboard. The animals are trained to pull the cart slowly down the rows. Next, the harvesters toss ears directly into the cart, keeping up with the progress of the animals.

The sideboard serves to direct over-thrown ears into the cart and harvesters soon learn to gauge the force of their throw without looking away from the harvest. By eliminating the need to turn and aim after each ear is harvested, then the time necessary to gather the ears from the ground and load them into nets, the efficiency of each worker is vastly improved. The investment represented by the sideboard would be minimal.

Wheat

In-Field Losses

Two sources of in-field losses are common in small grains. If plants are allowed to become too dry before being transported to the threshing area, significant shattering losses may occur. Immediate transport or wrapping the sheaves in a cloth or plastic are possible solutions. If plants are threshed too wet, not all the grain may be removed from the plant. These types of losses are variety-specific and can only be quantified through research.

Drying Threshed Wheat

If leftover seed is to be kept, it should be further dried to reduce the possibility of infestation or mycotoxin contamination.

General Recommendation

If future courses are contemplated, it would be advisable to include some of DIGESA's home economists. On small farms it is usually a female who is most involved in the inspection of stored grain, since she is usually the one who removes the grain from store, checks for bad grains, and prepares the food. It would be helpful if the extensionists (all female) who work with women's groups could teach identification of pests and damage, as well as storage management for pest control.

DESCRIPTION OF SHORT COURSE

A short course was presented at the Centro de Capacitación, DIGESA Region I. Teaching materials such as small microscopes and stands, pinned insects, Petri plates and agar, psychrometric charts in Spanish, sling psychrometers, certain slides and overhead transparencies, etc., were transported from Kansas State University (KSU) to Quezaltenango by the team. Course certificates and manual covers were also provided by KSU. The team carried Spanish manual originals from which certain sections were selected and/or expanded. Two sections were prepared in-country to provide a finished original. Forty-five copies of the short course manuals were then prepared in-country.

Slides taken during the pre-course farm visits were used in the course. Other teaching materials collected and/or prepared on site included data relative to environmental and grain condition in storage, examples of common insects, and samples of damaged grain.

The course began September 18, 1984, and terminated September 21, 1984. Thirty-three persons (see list below) participated in discussions, lectures, practices, and work sessions in the following subjects:

Grain structure

Physical, chemical and biological changes during storage

Microorganisms

Grain drying/equilibrium moisture content

Stored-grain insects

Rodents

Loss and pest control

The last session of the course was utilized in small groups. Each group prepared and gave a presentation over one of the following: advantages and disadvantages of the common maize storage methods, recommended cultural and

sanitation practices to reduce storage loss on the small farms of the Altiplano, alternative drying methods for ear maize, and economics of various storage structures, considering the levels of loss in each. Flip charts were prepared for each presentation so that the entire group could discuss the content of each presentation.

An evaluation form (see compilation below) was completed by each participant. The evaluations were filled out in time to prepare a review session based on the participants' suggestions.

APPENDIX I

EVALUATION OF COURSE

Numbers shown in the right-hand column are means of 27 answers to that item.

Indicate to what extent the following subjects are appropriate for your work:

	Not Appropriate 1	2	More or Less Appropriate 3	4	Very Appropriate 5
Structure of grains					(4.5)
Physical, chemical and biological changes of grain during storage					(4.2)
Microorganisms					(4.3)
Drying of grain					(4.1)
Insects of stored grain					(4.7)
Rodents					(4.3)
Control of insects and losses					(4.4)

Indicate to what extent you understood the subjects of the course:

	Not Appropriate 1	2	More or Less Appropriate 3	4	Very Appropriate 5
Structure of grains					(4.6)
Physical, chemical and biological changes of grain during storage					(4.2)
Microorganisms					(4.5)
Drying of grain					(4.5)
Insects of stored grain					(4.8)
Rodents					(4.8)
Control of insects and losses					(4.8)

Comments on the course The course has been adequate, practical, and well designed to understand all the subjects; It could be improved if more practices were incorporated; It was a very good course. Besides reminding me of the problems on grain storage it will help me when putting it in practice; Interesting, I learned many useful things, especially microorganisms and its development on stored grains; Well prepared; It was very good course but could be improved increasing the practices; Practical, refreshed forgotten concepts; Very good; It would be convenient to make field trips to farms and large warehouses (INDECA); Very helpful for the extension work we do. Very good; Very well conducted. I would like to receive more literature in Spanish on storage and conservation of basic grains; Very good; Efforts of sponsoring institutions have been great. Very well informed. I think it is necessary to organize a course with the view towards the rural area conditions. Congratulations!; Excellent, many of the topics were reminders of courses taken at the University and it updated our knowledge. Congratulations to the lecturer for his knowledge of the subject and his good Spanish; Acceptable, remarks marked (3) - due to the fact that they are more complex subjects therefore require a more complete study. In this case, being the apprenticeship intensive, it gives the opportunity for further research on the subject; A very interesting course for those of us who know about the problems in the field, to be able to help preserve the grains better; A good and complete course. In the future more courses like this should be planned; An interesting course by its applied methodology in development and its didactic support; Fairly good course especially for the material made available and instructions given, conducted very well and clearly; Very good course. Congratulations!; The point that the farmers' conditions are bad was made clear, all efforts must be aimed at making the best use of available resources; Very good. There should be a follow-up of the same type extending the one and making emphasis on some of the subjects.

APPENDIX II

LIST OF PARTICIPANTS

DIGESA

Victor Manuel Mayorga S.	Quezaltenango
Miguel Angel Vicente G.	Quezaltenango
Manuel Antonio Ordonez C.	Quiche
Carlos Alfonso Barrios L.	San Marcos
Eduardo Gamaliel Cifuentes M.	San Marcos
Jose Luis Navarro	Totonicapán
Carlos Rolando Juarez	Totonicapán
Julio Fernando Say M.	Quiche
Walter Rodrigo Tuy O.	Solola
Raymundo Gomez Hernandez	Huehuetenango
Jorge A. Mota L.	Huehuetenango
Jorge A. Morales M.	Huehuetenango
Carlos H. Gomez Q.	Solola
Hernando Mendez Alfaro	Huehuetenango
Carlos Humberto Marroquin A.	Quiche
Miguel Eduardo Garcia	Quiche
Pedro Jacinto Enriquez	Quiche

ICTA

Rolando Arturo Estrada F.
Jose Vicente Martinez A.
Odio Perez Ixchap
Salvador Bolanos
Gustavo Adolfo Tovar
Eduardo Garcia Turnil
Juan Antonio Bolanos
Miguel Angel Garcia de Leon
Miguel Ortiz
Luis Enrique Santizo F.
Manuel A. Alonzo P

INDECA

Hector Gustavo Gonzales S.
Jorge Luis Berreohgo G.
Julio Cesar Palacios H.
Hector Augusto Sologaistoa L.
Ricardo Regil Escobar

APPENDIX III

SCHEDULE OF FARM VISITS

Date	DIGESA Head Office	Places Visited
September 7	Quezaltenango	Sibilia, San Carlos Sija, San Isidro de Olintepeque
September 8	San Marcos	San Pedro Sacatepéquez, Tejutla
September 10	Huehuetenango	Chiantla, Sibilá
September 11	Totonicapán	San Francisco El Alto, Momostenango
September 13	Quiché	Joyabaj, Chinique

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APPENDIX IV

LIST OF PERSONS CONTACTED

USAID/Guatemala

Cecil McFarland	Project Officer
Gilberto Santa María	Assistant Project Officer
Geraldine Larraondo	Secretary - Project Officer

Small Farmer Diversification Project 520-0255

Bill Ross	Technical Team Leader
Gary Smith	Project Economist, USDA
Carlos A. Arjona M.	Coordinator of Project
José Luis Monterosso	Project Sociologist

INDECA

Francisco Higueros	Head, Department of Quezaltenango

ICTA

Marco Maldonado	Director, Region I

DIGESA

Domingo Conde	Director, Region I
Josue Salanic	Supervisor
Rudi Runge	Supervisor
José Bejola Diaz	Jefe Sub-Regional
Victor Manuel Merida	Supervisor
Marco Antonio Rivera	Supervisor
Mario Cabrera	Supervisor
Luis Alberto Gutiérrez	Supervisor
Rafael Velázquez	Supervisor
Carlos Seleno	Extension Agents (promotores)
Belgai Santizo	
Raymundo Gómez	
Jorge Niota	
Simón Argueta Xiloj	
Manuel Arnulfo Pelico	
Carlos Rolando Juárez	
Rodolfo Chan	
Edgar Niotan	
Gonzalo Figueroa	
Walter Rivera	
Carlos Marroquín Alpírez	
Carlos Múñoz	
Manuel López	
Marcos Ordóñez	
Carlos Bamac	
Carlos Barrios	

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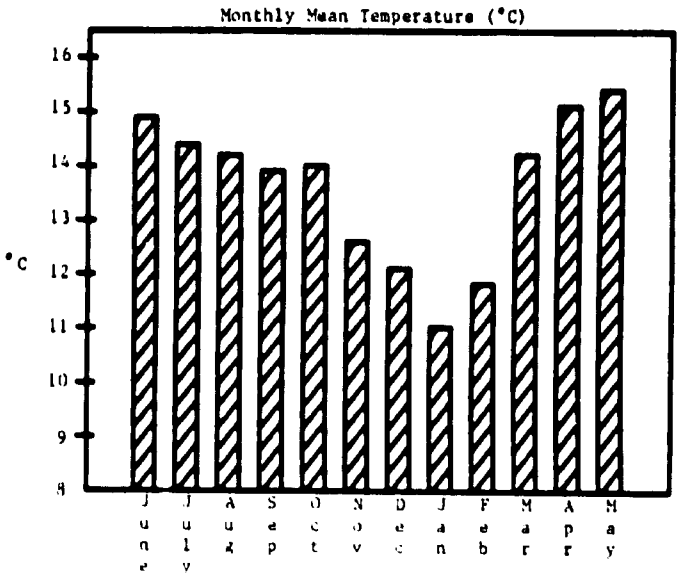
Producers

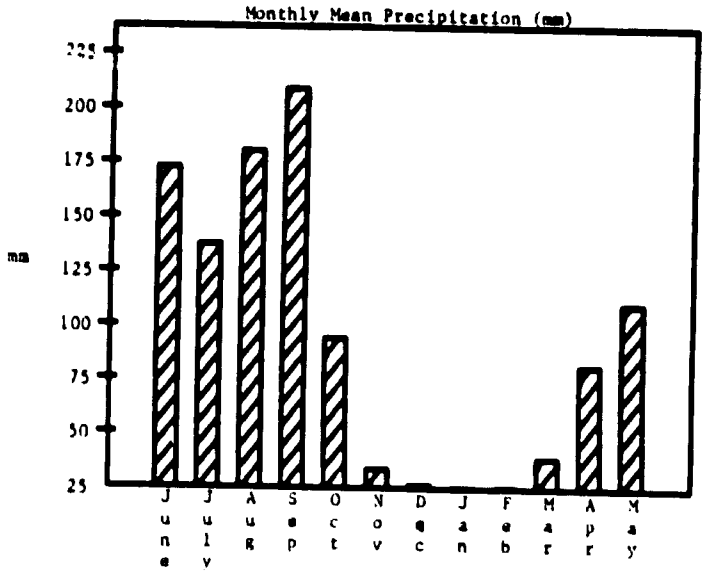
Armando Granejo
Mario Natividad Arreaga
Pablo Orozco
Santos Gutiérrez
Benito Canastu
José Nery Pérez
Sebastián Ventura Calel
Jorge Navarro
Ramón de León
Julian Cifuentes
Ramón López
Cayetano Alberto Itzep
Demetrio Argueto

APPENDIX V

RELEVANT CLIMATOLOGICAL DATA

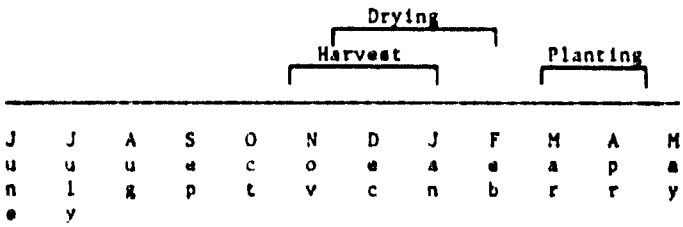


Three-year means 1979-81, Quezaltenango, 2,400 m



Three-year means 1979-81, Quezaltenango, 2,400 m

Typical Periods of Activity for Basic Grains



Two-Year Average* Monthly Relative Humidity Values (%)

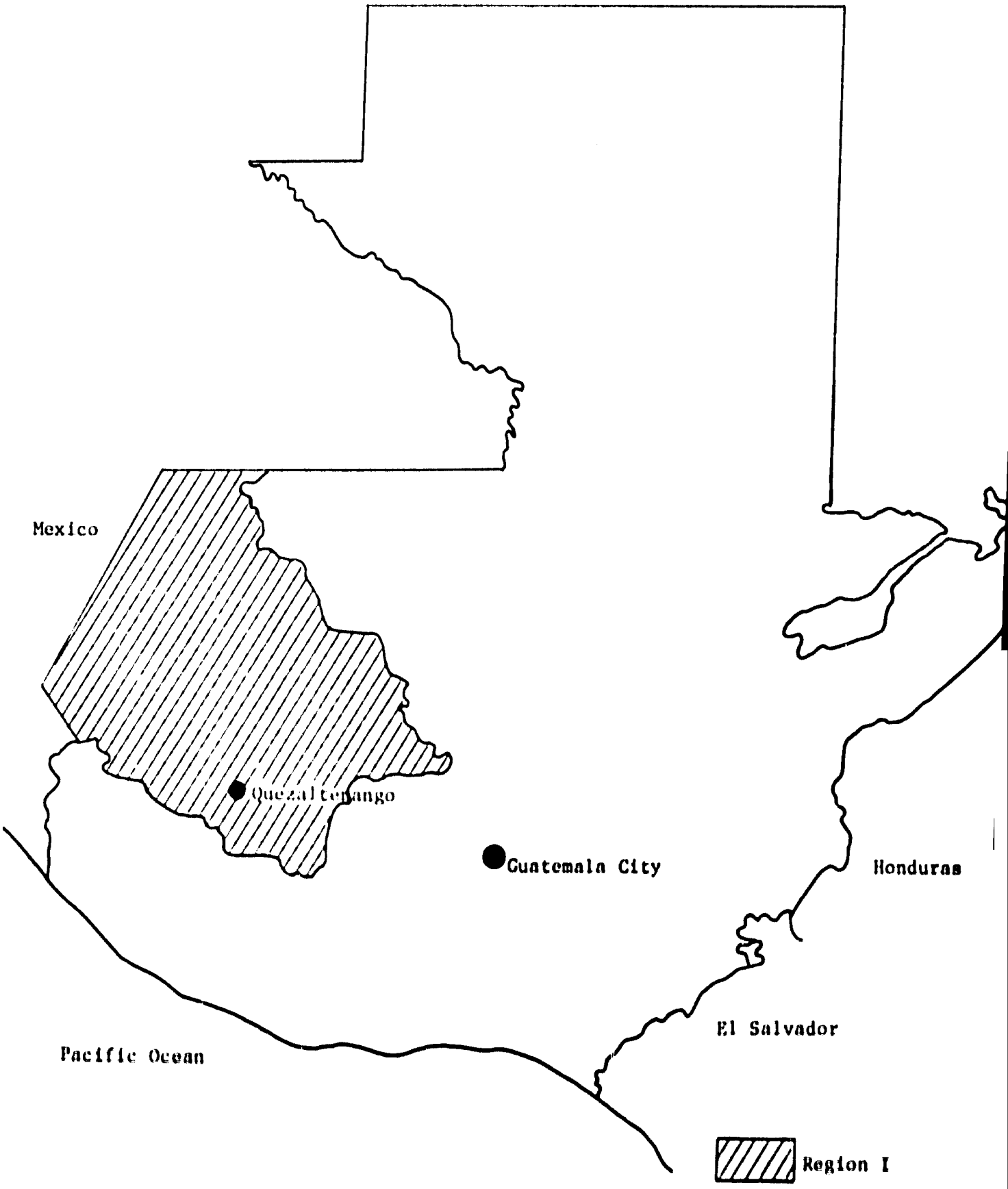
Month	Mean	Maximum	Minimum
Oct	79	100	10
Nov	77	100	26
Dec	71	100	12

The two-year average** relative humidity values at 1:00 p.m. during November 20 61%.

*1979, 1980 Huehuetenango, 1,900 m.

**1982, 1983 Quezaltenango, 2,400 m.

Area of Project 520-0274



APPENDIX VI

RESUMEN

Esta consultoria se llevó a cabo como un adjunto al trabajo del Proyecto de Diversificación para los Pequeños Agricultores del Altiplano, Región I, Guatemala. El equipo, acompañado por personal de Dirección General de Servicios Agrícolas (DIGESA), visitó distintas zonas ecológicas del Altiplano con objetivo de conocer las condiciones, entrevistar a los agricultores acerca de las prácticas post-producción y tomar datos sobre los parámetros relacionados con el manejo y almacenamiento de los granos básicos. Se preparó un informe con evaluaciones y recomendaciones para el uso de USAID/Guatemala, el Equipo de Asistencia Técnica (EAT) del Proyecto de Diversificación, tanto como para el personal de Instituto de Ciencias y Tecnología Agrícola (ICTA) y DIGESA. Las conclusiones y recomendaciones importantes son las siguientes: (1) El almacenamiento de maíz en lugares más altos que 7,200 pies (2,200 metros), tanto como el de frijol en todo el Altiplano está siendo manejado exitosamente con las técnicas actuales. No hace falta más investigación a menos que haya cambios mayores en los procedimientos antes de almacenar. (2) El almacenamiento de maíz en las zonas más bajas que 7,200 pies (2,200 metros) es más variable y problemático. El equipo recomendó que se investiguen los aspectos económicos del almacenamiento hermético en toneles en lugares donde hay pérdidas en el almacenamiento. (3) Se recomendó un grupo de prácticas culturales y de saneamiento para proveer un enfoque integrado de control de plagas en el maíz almacenado en las zonas más bajas que 7,200 pies (2,200 metros). (4) El equipo también recomendó que se investiguen ciertas prácticas del sistema post-cosecha del trigo. (Se nota que el trigo sirve como el producto de venta para la mayoría de las fincas del Altiplano, y así no se guarda en las fincas.) La investigación debe dirigirse al conocimiento del nivel de pérdida en los procesos indicados, tanto como saber si los picholeros recuperan las pérdidas.

El equipo presentó un curso para 33 participantes de DIGESA, ICTA e Instituto Nacional de Comercialización Agrícola (INDECA) a partir del 18 de septiembre hasta el 21 del mismo en el Centro de Capacitación de DIGESA en Quezaltenango. En el curso intensivo se impartieron todos los principios básicos del buen almacenamiento de los granos. También hubo discusiones sobre la adaptación de las técnicas de control de plagas a las específicas condiciones de las pequeñas fincas del Altiplano. Diapositivas de las condiciones encontradas en las fincas durante las visitas fueron usadas en la docencia. Grupos de participantes elaboraron e hicieron presentaciones acerca de lo siguiente: características del almacenamiento en sus zonas, técnicas apropiadas de control de plagas, técnicas apropiadas del secamiento, ventajas y desventajas de las diferentes formas de almacenar maíz, y los aspectos económicos de las distintas formas de almacenar el maíz.

APPENDIX VII

RECOMENDACIONES Y POSIBLES AREAS DE INVESTIGACION

Maíz

Las Buenas Prácticas del Almacenamiento

Donde el almacenamiento del maíz, sea en tapancos, cajones, galeras, o trojas esté comentado en relación a problemas y pérdidas, el siguiente grupo de técnicas debe de recomendarse. (Este enfoque integrado fue elaborado en gran parte por el personal de DIGESA, como parte del Curso Intensivo.)

A. El Buen Saneamiento - Hay que limpiar el almacén antes de guardar la nueva cosecha. Basura y grano infestado debe removerse y quemarse o enterrarse. Hay que lavar los costales con detergente, secándolos al sol. Los almacenes pueden desinfestarse con Malathion u otro insecticida recomendado, si no hay peligro de contaminar la casa.

B. Selección y Apartado - Es recomendable dejar unas capas de las tuzas largas y talladas, ya que proveen protección contra los hongos e insectos. Las mazorcas infestadas o que tienen la tuza dañada deben de separarse físicamente del maíz bueno. En las zonas más bajas, esta separación debe incluir hasta llevar el maíz dañado a otro cuarto para evitar la infestación del bueno por el dañado.

C. Secamiento Rápido - Deben colocar las mazorcas húmedas sobre techos, patios, o sobre plástico (el negro es el mejor) si van a secar en el suelo. Deben buscar lugares donde las mazorcas estarán expuestas al movimiento del aire. No deben colocarse directamente sobre el suelo, donde se remojan durante las horas de temperaturas bajas. Entre más rápido el secamiento, menos chance hay de arruinarse.

D. Mantener Temperaturas Frescas - Los cajones se deben colocar dentro de la casa si es posible. Toda clase de almacén debe ubicarse de manera que siempre esté en la sombra.

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E. Caso Especial - Si el maíz ya está muy infestado (sobre todo si está sin tuza) recomendar lo siguiente: Primero, seque el maíz más si es posible. Después, ya que la probable causa del daño es la palomilla Sitotroga, que se mantiene mejor en el maíz en mazorca, desgrane el maíz. Colocar el grano en toneles si es posible, o bien en un buen cajón. Finalmente, fumigar si es factible desde un punto de vista económico y físico.

Almacenamiento a las Alturas Mayores

El maíz almacena bien a las alturas mayores (más de 2,600 m) y medias (entre 2,600 m y 2,200 m). Si no hay cambios mayores en el sistema, no lo necesita investigar más. Si, por ejemplo, hay un aumento en la incidencia de desgrane mecánico, más secamiento será necesario para asegurar un almacenamiento exitoso.

Almacenamiento a las Alturas Menores

A menos de 7,200 pies (2,200 metros), se notaron varios problemas significantes en el almacenamiento. Parece haber cupo para la investigación y extensión de las mejores técnicas actuales.

Una solución que se encuentra comunmente a través de Centro America, menos las costas, y que fue observado en el Altiplano, es el uso de toneles herméticos. Se seca el maíz hasta menos del 15% (b.h.), se desgrana, se limpia y se carga durante las primeras horas del sol para que el grano esté fresco pero sin condensación. Los toneles se sacuden durante el llenado y se llenan a su máxima capacidad de manera que el grano quede compacto. Los toneles se tapan y se colocan donde siempre hay sombra. Después de poco tiempo la respiración de los mohos deja sin oxígeno el ambiente adentro y el crecimiento de los mohos e insectos para.

Las condiciones bajo las cuales el almacenamiento en toneles es económico depende de su precio tanto como el nivel de las pérdidas en los métodos alter-

nativos de almacenaje. Basado en la necesidad de almacenar 26 qq de maiz a Q8.00/qq, y que--como nos informaron--el tonel cuesta Q10.00, se paga la inversión dentro de 5 años solamente si reducen las pérdidas en un 7%. Siete toneles de 4 qq de capacidad c.u. son necesarios; a razon de Q10.00/tonel = Q70.00. La cantidad equivalente a Q8.00/qq maíz = 8.75 qq. Así 8.75 qq de maíz habrán que ahorarse sobre un período de 5 años para repagar la inversión. La pérdida por año que debe eliminarse a fina de ahorrar 8.75 qq en 5 años es de 7%, ya que (0.067) (26 qq/año) (5 años) = 8.75 qq maíz. Pintados y con buen mantenimiento, los toneles duran más de 30 años en uso continuo. Con las técnicas apropiadas, realmente no hay pérdidas en toneles.

Técnicas Eficientes de Cosechar

En la mayoría del Altiplano, el maíz se produce en campos pequeños de terreno muy quebrado en los cuales las actuales técnicas de cosecha y transporte son adecuados.

Donde hay extensiones grandes de maíz en terreno más o menos plano, y con fuerza animal, el uso excesivo de fuerza humana en la cosecha parece más cosa de tradición que la tecnología apropiada.

En esta situación el equipo recomienda la introducción de la siguiente innovación como método experimental: Primero, a la carreta tradicional se agrega un lado alto (1.5-2.0 m). Después, se entrenan los animales para que pasen lentamente por los surcos. Los trabajadores tiran las mazorcas directamente a la carreta, cosechando a la misma velocidad que andan los animales.

El lado alto sirve para captar las mazorcas que se tiren con mucha fuerza, mientras que los trabajadores pronto aprenden apuntar los tiros sin mover la vista de la cosecha. Así se elimina la necesidad de dar vuelta cada vez para tirar, tanto como el tiempo perdido en recoger el montón de maíz y cargarlo en redes, así aumentando mucho la eficiencia de cada trabajador.

Trigo

Pérdidas en el Campo

Hay dos tipos de pérdidas comunes en los procedimientos en el campo en cuanto a los pequeños granos. érdidas por desgrane ocurren si las plantas se secan mucho antes de transportarse. Transporte inmediato o envolver las gabillas en tela o plastico, puede solucionar el problema. Por el otro lado, si las plantas se trillan muy húmedas, hay pérdidas porque la máquina no puede extraer todo el grano de las matas. Solamente con investigación se cuantifican estas pérdidas que varian segun la variedad.

Secamiento Despues de Trillar

Si la semilla sobrante se va a guardar y utilizar, hay que secarla más para evitar infestación o contaminación por las micotoxinas.

Recomendación General

Futuros Cursos

Ya que la práctica de sacar grano diariamente, escojerlo y prepararlo sirve como una clase de inspección del grano, siendo la mujer quien lo hace, sería bueno para futuros cursos, incluir a algunas de las extensionistas mujeres de DIGESA. Así los conocimientos sobre la identificación de plagas y daños, y el control del mismo puede llegar a los miembros de la familia talvéz más involucrados en el manejo del producto almacenado.