Farm level storage losses in Eastern Nepal (G157)

Tropical Products Institute

G157

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R. A. Boxall and R. Gillett*

*Voluntary Service Overseas

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Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU

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NOTE

The following abbreviations are used in this report:

FAO	Food and Agriculture Organization
GRS	Gurkha Reintegration Scheme
HMGN	His Majesty's Government of Nepal
KHARDEP	Kosi Hill Area Rural Development Programme
LAC	Lumle Agricultural Centre
ODA	Overseas Development Administration
PAC	Pakhribas Agricultural Centre
TPI	Tropical Products Institute
VSO	Voluntary Service Overseas

Summaries

SUMMARY

A study of farm level storage losses was undertaken in the Eastern Hills of Nepal between May 1979 and June 1980. The project was a collaborative one involving the Gurkha Reintegration Scheme and the Kosi Hill Area Rural Development Programme, both of which are supported by the UK Overseas Development Administration. Technical support and advice to the project was provided by the Tropical Products Institute during three consultancy visits.

The project began with a study of the minor wheat crop which provided the opportunity for field staff to gain essential experience and to develop a methodology for assessing storage losses.

The main study of maize losses was undertaken between July 1979 and June 1980 and a limited study of losses occurring during the storage of paddy was conducted between November 1979 and June 1980.

The published methodology for post-harvest loss assessment had to be adapted to the difficult field situation in the hills of Nepal and a simple method of estimating weight loss from observations of the percentage of damaged grains in a sample was used in the assessment of maize losses. The method, when compared with the preferred bulk density method of estimating weight losses, proved to be adequate. Modified bulk density methods were used to determine losses in wheat and paddy. The results of the survey demonstrated that farm level storage losses were lower (approximately 5%) than previously reported (10–30%) and in consequence tentative proposals for a programme to reduce losses by introducing new storage structures and pesticides, even if practical to implement, were shown to be unjustifiable.

RÉSUMÉ

Une étude des pertes au stockage au niveau des fermes a été entreprise dans les Montagnes de l'Est du Népal entre mai 1979 et juin 1980. Ils s'agissait d'un projet réalisé en collaboration par le Projet de Réintégration Gurkha et le Programme de Développement Rural de la Zone de Montagne Kosi, tous deux subventionnés par l'Administration de Développement Outre-mer (Royaume-Uni). Le projet a bénéficié de l'aide et des conseils techniques de l'Institut des Produits Tropicaux au cours de trois visites de consultation.

Le projet a commencé par une étude de la récolte peu importante de blé, qui a fourni l'occasion au personnel agricole d'acquérir l'expérience fondamentale et de mettre au point une méthode de détermination des pertes au stockage.

La principale étude des pertes de maïs a été menée entre juillet 1979 et juin 1980 et une étude limitée des pertes se produisant pendant le stockage du paddy a été conduite entre novembre 1979 et juin 1980.

La méthode publiée pour l'évaluation des pertes après récolte a dû être adaptée à la situation agricole difficile dans les montagnes du Népal et une méthode simple d'estimation de la perte pondérale à partir d'observations du pourcentage de grains détériorés dans un échantillon a été utilisée pour la détermination des pertes de maïs. La méthode, comparée à la méthode de densité globale proposée pour l'estimation des pertes pondérales, s'est révélée appropriée. Des méthodes de densité globale modifiées ont été utilisées pour déterminer les pertes de blé et de paddy. Les résultats de l'enquête ont révélé que les pertes au stockage au niveau des fermes étaient plus faibles (environ 5%) que celles rapportées antérieurement (10–30%) et, en conséquence, on a montré que les propositions éventuelles pour un programme en vue de réduire les pertes en introduisant de nouvelles structures de stockage et de nouveaux pesticides, même si elles sont réalisables en pratique, ne peuvent se justifier.

RESUMEN

Se realizó un estudio de las pérdidas de almacenaje a nivel de granja en las colinas orientales del Nepal entre mayo de 1979 y junio de 1980. El proyecto fue de tipo colaborativo, involucrando el Esquema de Reintegración Gurkha y el Programa de Desarrollo Rural de la Zona Montañosa Kosi, ambos de los cuales son apoyados por la Administración de Desarrollo de Ultramar (Reino Unido). El apoyo y asesoramiento técnico al proyecto fue aportado por el Tropical Products Institute (Instituto de Productos Tropicales) durante tres visitas consultivas.

El proyecto comenzó con un estudio de la pequeña cosecha de trigo, el cual brindó la oportunidad al personal sobre el terreno de obtener una experiencia esencial y de desarrollar una metodología apropiada para evaluar las pérdidas de almacenaje.

El estudio principal de pérdidas de maíz fue llevado a cabo entre julio de 1979 y junio de 1980, y un estudio limitado sobre las pérdidas ocurridas durante el almacenaje de arroz sin desgranar fue realizado entre noviembre de 1979 y junio de 1980.

La metodología publicada para efectuar una evaluación de las pérdidas posteriores a la recogida tuvo que ser adaptada a la dificil situación del terreno en las colinas del Nepal, y se utilizó un método sencillo para calcular la pérdida de peso a base de observaciones sobre el porcentaje de granos dañados hallados en una muestra para la evaluación de las pérdidas de maíz. El método demostró ser adecuado, cuando se comparó con el procedimiento preferido de calcular las pérdidas de peso por la densidad a granel. Se utilizaron métodos de densidad a granel modificados para determinar las pérdidas ocurridas en el trigo y en el arroz sin descascarar. Los resultados del estudio demostraron que las pérdidas de almacenaje a nivel de granja fueron más bajas (aproximadamente un 5%) que las anteriormente establecidas (10–30%), y por consiguiente no se consideraron justificables unas propuestas provisionales de un programa para reducir las pérdidas mediante la introducción de nuevas estructuras de almacenaje y pesticidas, aun cuando resultaran practicables de poner en efecto.

Farm level storage losses in Eastern Nepal

INTRODUCTION

Post-harvest losses in Nepal are claimed to be unacceptably high and a recent government estimate puts the loss of food grains during storage at the farm level at around 10% (HMGN Ministry of Finance, 1978). There is, however, little published information regarding the level and causes of post-harvest losses in Nepal. The FAO, in an analysis of a survey of post-harvest losses in developing countries, records a figure of 15% as the loss during farm storage over a 3-4 month period. The causes of loss are unspecified (UN:FAO, 1977). Rana and Ganesh (1977) attributed weight losses of 10-30% to insects alone following a survey of farm grain stores in fifteen Terai (Plains) and Hill districts in the country. In a follow-up comparative trial of traditional stores and improved storage bins, they demonstrated a weight loss of 19.3% in traditionally stored paddy in the Terai, over a full storage period.

The assessment of post-harvest losses in Nepal is exceptionally difficult because of the severity of the terrain which poses serious problems of access and communication in many parts of the country, particularly in the hill areas. This in turn introduces complexities into the post-harvest system.

The intensive pattern of sampling and sample analysis which has been employed in earlier farm-level storage loss assessment studies (Adams and Harman, 1977; Boxhall *et al.,* 1978) cannot readily be applied in such a situation.

This project was limited to a small area of the Kosi Zone in the Eastern Hills and concentrated upon the major food crop of the area, namely maize, although supplementary studies of wheat and paddy were undertaken. However, it is quite possible that the broad conclusions reached by this study may be applicable to other locations well beyond the boundaries of the project area, although the possible need for confirmatory studies in other areas is recognised.

The three crops studied, maize, wheat and paddy, together with millet and barley, comprise the major food grains of Nepal, accounting for approximately 90% of the country's total cropped area. On a national level, paddy is the main crop, taking 52% of the area under food grains for 64% of the total food grain production, followed by maize and lastly by wheat which is a relatively new crop. In the Hills, however, maize is more important (58% of national maize production). Wheat in the Hills accounts for almost 30% of national wheat production and paddy about 19% of national paddy production (HMGN Ministry of Agriculture, Food and Irrigation, 1979).

The Gurkha Reintegration Scheme (GRS), which is funded by the UK Overseas Development Administration (ODA), operates two agricultural stations, the Lumle Agricultural Centre (LAC) in the Central Hills of Nepal and the Pakhribas Agricultural Centre (PAC) in the Eastern Hills. Both Centres have had some limited involvement in the improvement of grain storage at the farm level and much background information regarding local storage practices has been accumulated. However, no extensive surveys of losses had been undertaken. In late 1978, following the appointment of a Voluntary Service Overseas officer (VSO) with special responsibility for grain storage, PAC prepared a proposal to undertake a survey of storage losses on farms in the vicinity of the Centre. The PAC target areas of extension activity lie within the boundaries of a long-term rural development project — the Kosi Hill Area Rural Development Programme (KHARDEP) — which is also supported by the ODA. KHARDEP expressed interest in collaborating with PAC in the survey of losses at an early stage and subsequently provided a team of investigators. Technical supervision was provided by PAC. As a result of the involvement of KHARDEP, the project was expanded and was able to cover a much wider area than was originally planned. The Tropical Products Institute (TPI) provided technical support and advice to the project through three consultancy visits. The project, which was based on the PAC in Dhankuta District of the Kosi Zone, began in May 1979 with the following objectives:

1 To undertake a preliminary investigation of losses occurring during the storage of wheat at the farm level to gain experience and to develop a suitable method of loss assessment which might be applied in a major study of maize losses.

2 To determine the extent and causes of losses occurring during the storage of maize at the farm level in the Eastern Hills of Nepal.

3 To undertake a limited investigation of the extent and causes of loss occurring during storage of paddy at the farm level.

4 To make suggestions for future work on grain storage that might be undertaken by PAC/KHARDEP.

PROJECT LOCATION

The KHARDEP area, covering the four hill districts of the Kosi Zone (Dhankuta, Terhathum, Bhojpur and Sankhuwasabha), lies between the Northern Himalayas and the Mahabharat Lekh Range which separates the middle hills from the Terai. The area, which measures about 125 km from north to south and between 50 and 90 km from east to west, covers 6,375 km^2. Further details of the KHARDEP area are given in a report of an extensive baseline survey of the area carried out in 1977–78 (Conlin and Falk, 1979).

Between the Mahabharat Lekh Range and the mountainous area of Northern Sankhuwasabha District lie the middle hills where the loss assessment project was located. The terrain is deeply incised by the two main rivers, the Arun and the Tamur, and their tributaries. Slopes are steep and the elevation varies from about 270 to 2,700 m. There are relatively few flat areas, covering only a few hectares and all of which lie close to the main rivers.

The population lives in scattered, isolated, households rather than in clearly defined villages although houses are generally concentrated in the drier upland areas between 690 and 1,650 m. The households are grouped into administrative units, the village *panchayats,* each of which is sub-divided into 9 wards. The boundaries of the panchayats have recently been redefined on the basis of natural boundaries and population so that the village panchayats in this area have a population of between two thousand and five thousand.

Ambient temperature and the availability of water greatly affect agricultural practices in the hills. In areas of high temperature (i.e. low altitude) and where water is available, multiple cropping is practised with cropping percentages of up to 300%. At the other extreme, at high altitudes (1,800 m and above) where crops are solely rainfed, only one maize crop is grown although this may be undercropped with potatoes (*see* Figure 1).

Land that can be irrigated or which has sufficient water holding capacity to support a crop of rice is known as *khet* land. It is highly prized as rice is the preferred crop and can, in theory, be more heavily cropped. Land that cannot be irrigated is known as *bari* and is mainly used for maize cultivation with secondary crops of millet, wheat, pulses and potatoes. Many of the poorer farmers cannot afford khet land and rely on small areas of bari. In order to obtain sufficient food, the bari land is often more intensively cropped. Some richer rice farmers do not grow second crops as the yield of the main rice crop is reduced and they sometimes find difficulty in marketing the second crop.

Annual rainfall in the middle hills varies between 650 and 1,900 mm depending upon aspect and situation. The monthly rainfall means from three stations in the KHARDEP area are given in Table 1.

Many parts of the country, including the Eastern Hills were seriously affected by a drought in 1979, the year in which the loss assessment study was undertaken. Even at Pakhribas, where rainfall is usually above the average for the area, the months of January, March, May and November were exceptionally dry (*see* Table 2).

Table 1

Mean monthly rainfall in millimetres for Dhankuta, Chainpur and Pakhribas

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly total
Dhankuta(1)	10	21	17	39	57	212	284	144	70	51	4	9	918
Chainpur(2)	11	12	18	52	153	208	326	289	198	66	16	1	1,350
Pakhribas(3)	11	23	38	64	132	263	406	339	155	74	54	54	1,613

Notes: (1) 1961–68, 1970
(2) 1961–70
(3) 1976–79

Table 2

Monthly rainfall in millimetres for Pakhribas for 1976–78 and for 1979

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly total
Mean 1976–78	13	20	51	66	163	257	383	370	161	68	68	50	1,670
1979	3.6	32	0.8	57	38	282	476	246	139	90	14	64	1,445

The period from March until May is critical for maize production, since the crop is sown in March and requires sufficient rainfall for germination. In 1979 the low rainfall resulted in poor germination, and severely stunted plants in many areas. Paddy was also affected by the drought, though not so severely, as farmers postponed their sowing and/or transplanting until sufficient rain had fallen. This did, however, result in the growing period extending into the colder season which caused sterility in plants in some areas.

Ambient temperatures vary with altitude, aspect and exposure. At Pakhribas for example, at 1,590 m on a south-facing slope, monthly means vary from 10.5°C in January to 20°C in June, whereas at Chainpur, at 1,260 m on a ridge top, monthly means vary from 13°C in January to 24°C in June.

Since KHARDEP had already undertaken a general agricultural and socio-economic survey (Conlin and Falk, 1979), it was decided to select panchayats, wards and households for the loss assessment survey on the basis of the random selections made by KHARDEP. In this way it was possible to utilise existing background information, thus reducing the amount of preliminary survey work. Furthermore it was considered that the results of the loss assessment survey might provide supportive data for future studies, e.g. of food consumption patterns, nutrition surveys, that might be undertaken by KHARDEP.

Owing to the difficult terrain, only panchayats within 1-2 days travel of PAC were selected for the study. The sample households could only be reached on foot from PAC and it was felt that there was little to be gained from locating field investigators in areas remote from PAC. Field staff were then able to return grain samples to PAC relatively quickly for analysis, and senior project staff were able to supervise field operations adequately. Furthermore it was considered that the major cropping patterns found in the selected panchayats were representative of those found in the PAC target area as a whole and of Terhatum district and Dhankuta district (north of the River Tamur).

HARVESTING AND STORAGE PRACTICES

Wheat

Wheat is harvested in April and May and is generally stored for 2-3 months, i.e. into the monsoon period which is generally considered to be a period of significant storage insect pest activity. In an earlier review of storage practices in the Pakhribas area, Cunningham and Howarth (1978) suggested that the stored wheat crop was important in maintaining insect populations throughout the monsoon period thus providing a source of infestation for the maize which was brought into the house when it was harvested towards the end of the monsoon. The important insect species found infesting wheat were *Sitotroga cerealella, Sitophilus oryzae* and *S. zeamais. S. granarius* was also occasionally reported.

Wheat is stored in a variety of containers ranging from small pots and sacks to large basket-type containers *(bhakari)* and mud bins *(dhikuti)* built inside the dwelling house. In one panchayat (Srijung) in the northern part of the project area, wheat was generally stored unthreshed, the bundles of straw being hung under the eaves of the house, but occasionally unthreshed ears were stored in bhakaris. Because of land pressure the wheat crop in this area is often harvested early and at a high moisture content and these storage practices are adopted to allow the grain to dry adequately.

Maize

The main maize crop is generally harvested between August and September although maize grown on the low land in the valleys may be harvested in early July whilst that grown at higher altitudes (1,800 m) may not be harvested until October.

In low lying areas, maize is harvested before it is fully mature (at moisture contents often in excess of 30%) because of the pressure on the land to plant a millet crop (on bari land) or a rice crop (on khet land). If the khet maize crop is still very immature at the normal harvesting time, it may often be ploughed in so as not to delay the planting of rice. This happened during the period of the study because the drought had a serious effect on the development of the maize crop.

The duration of storage varies but large quantities of maize cobs (equivalent to 700 kg of shelled maize) may be stored for periods of up to 10-12 months. In areas where maize is the only cereal crop (usually at higher altitudes), the storage period is often extended and the maize may remain untouched for several months after harvest, the population consuming potatoes as the staple food.

Three methods of maize storage are common. The cobs, still in sheath, are usually stored on a wooden frame or platform *(thangro)* erected close to the house, hung under the eaves or stored on the upper floors inside the house, either in loose piles or in well-constructed stacks. Storage inside the house may only be temporary, particularly where cobs are harvested in the monsoon (i.e. at the lower altitudes), the cobs being transferred to the thangro after the rains; but long-term storage inside the house is not unknown.

The date of harvesting varies with altitude and consequently different storage patterns can be observed, depending upon the period between harvesting and the end of the monsoon. Maize stored inside the house is often exposed to insect infestation from other stored crops, and earlier observations have indicated that losses in stored maize are likely to be more severe at the lower altitudes since the crop is harvested and brought into the house during the monsoon (July-August) when conditions are more conducive to rapid insect development (Cunningham and Howarth, 1978). At the higher altitudes maize is harvested towards the end of the monsoon, or even after the rains have finished, when conditions for insect development are less favourable. The harvested cobs are rarely taken into the house; instead they are stored on thangros or under the eaves immediately after harvest. Maize is often the only cereal crop grown at higher altitudes and the risks of cross-infestation are less.

The quantity of maize produced also affects the storage pattern. Space inside the house is often limited and so farmers tend to store their grain outside as soon as possible. However, during the period of the loss assessment survey more farmers than usual, at least in the drought affected areas, stored their maize inside the house, the quantities harvested being considered too small to justify storage on a thangro.

Maize cobs are withdrawn from store and shelled as required, the shelled grain being kept in small quantities in baskets, pots etc. immediately prior to consumption. Very occasionally larger quantities of shelled maize may be stored after shelling for later seed selection, usually towards the end of the storage period.

Insect infestation on stored maize in the project area was extremely variable. The most common insect was *Sitotroga cerealella* but weevils *(Sitophilus granarius, S. oryzae* and *S. zeamais)* were also found regularly.

Paddy

There may be two crops of paddy each year; the main crop is harvested in November/December and the early *(tauli)* crop, which is harvested in June/July, is only grown at low altitudes on land that can be irrigated throughout the year. Paddy is generally stored in larger structures than those used for wheat e.g. dhikuti, bhakari and *kota.* Infestation of paddy by *Sitotroga cerealella* is common. Insect activity increases from April onwards and it is likely that insects from the paddy as well as from the wheat infest the newly-harvested maize which is brought into the house at the end of the monsoon.

Paddy is often harvested at high moisture contents of up to 20%. The bundles of paddy are then left lying in the fields for 1-2 weeks before being taken to the house for threshing. Where fields are far from the house threshing may be carried out in the field on a specially prepared threshing floor, usually by hand, but a second threshing using cattle may be carried out to recover more grain. Greater care is taken in harvesting paddy than in harvesting wheat or millet, firstly because it is regarded as a more valuable crop, and secondly because there are usually no conflicting demands for labour at paddy harvesting time.

The general storage patterns of the area under study are summarised in Figure 1.

Farm storage structures of the Eastern Hills of Nepal

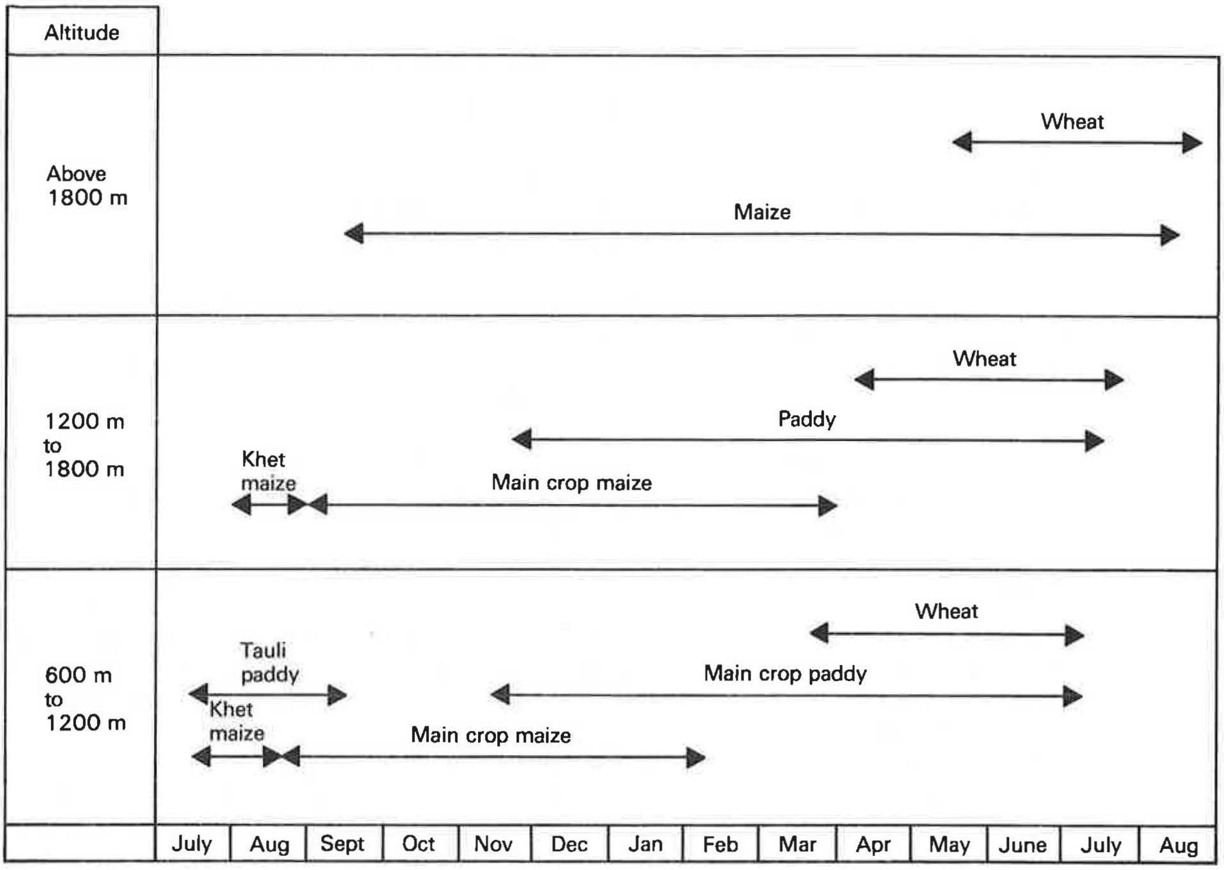
Dhikuti. A four-sided box or bin built of stone, mud or wood, inside the house, often utilising one or more of the existing walls. Usually no lid is provided. The capacity is variable but usually more than 70 kg. Most households have more than one, built along one wall of the house. Dhikutis are usually for storing rice, but they may be used for other crops.

Bhakari. A woven bamboo mat rolled into a cylinder and placed on end, on a mat. Mud is occasionally smeared onto the matting to seal holes. Lids are seldom used, but consist of a small straw mat. The capacity varies from 70 to 200 kg.

Kota. Similar to bhakari but with the bamboo base woven in. Capacity from 70 to 200 kg. A mud lining is commonly used. Kotas may be used for storing any type of grain but they are frequently used for seed grain.

Dalo. A small circular basket of bamboo raised on short legs. Capacity 20-40 kg. The dalo is often used for holding small quantities of threshed grain for milling or the milled product. Dalos are used for longer storage of surplus grain when all major structures are filled.

Figure 1
Storage calendar for major cereals: wheat, maize and paddy



Ghyampa. Earthenware pots with capacities between 15 and 40 kg commonly used for storing seed grain.

Tins. Biscuit tins and cooking oil tins with sealable lids are often used for storing seed grain. Capacities 10 to 20 kg.

Storage structures for maize

Maize is generally stored on the cob, and in sheath. When harvested during the monsoon, cobs are often first stored in loose piles on the top floor of the house. The cobs may later be stored in one of the following ways:

Stack. A stack of cobs may be built on the top floor of the house, either in the corner of the room or around a centre pole (supporting the roof of the house). Occasionally the stack may be built directly over a hole in the upper floor, immediately above the fire, so that smoke can penetrate the stack. The stack is built with the heels of the cobs always facing out in an attempt to reduce rodent damage.

Thangro. A narrow storage rack built outside the house. Poles are set up vertically with bases embedded in the soil. Onto these are tied horizontal poles, approximately 1.5 m from the ground. The outer layers of the maize cob sheaths are peeled back and used to tie cobs together in bunches before they are stacked onto horizontal poles.

Baha. Maize cobs are tied in bunches and hung directly under the eaves or strung on a pole hanging under the eaves. Cobs may be stored in this way temporarily before being placed on the thangro.

ORGANISATION OF THE PROJECT

The project design allowed for five areas of study each under the control of a field investigator and so five panchayats were selected. The final selection of panchayats and households was based on data provided by KHARDEP. Manpower availability and the scattered distribution of households within the panchayats were constraints on the number of households selected. As each household was to be visited once a month and the field investigators were required to return to PAC at least once a month (usually twice), it was considered that forty households per panchayat was a reasonable sample size for the main study of maize (fewer households were selected for the studies of wheat and paddy). For each panchayat two wards were first chosen at random and within each ward twenty farms were chosen, again at random, giving a sample size of two hundred households.

PAC provided two project supervisors, one for the duration of the project and one until January 1980 when he was re-assigned to other duties at PAC. KHARDEP provided all the field staff. Four field investigators were appointed initially for the study of wheat losses which was restricted to the four most important wheat growing panchayats. All four investigators had had previous field experience with KHARDEP and were familiar with the general situation in the panchayats and were used to living and working amongst the rural population. Before being posted to the field the investigators were briefed in loss assessment techniques. However, the study of wheat losses was designed primarily as a training exercise and one through which a methodology for the main study of maize losses could be developed. Before the start of the maize study a further two field investigators (one with previous experience) were appointed.

One investigator was allocated to each of the five panchayats and the sixth spent some time in each panchayat, helping the permanent investigator at peak sampling times. In this way he became familiar with the work in each area and was subsequently able to substitute for other investigators whenever they were sick or on leave. During the course of the study two field investigators left the project to continue higher education and replacements had to be found. On one occasion no hand-over period was possible but this did not seriously affect the field work. All field investigators had a maximum qualification of School Leaving Certificate (SLC)

The project began in early May 1979 and field work continued until June 1980. The minimum amount of equipment was used and laboratory bench space was provided at PAC. The project budget and notes on equipment are given in Appendix 1. The loss assessment methodology was based on that described in *Post-harvest grain loss assessment methods* compiled by Harris and Lindblad (1978) but some modification was necessary because of the constraints of communications between sample areas and PAC, manpower availability, and local traditions and beliefs. Following a preliminary survey of a small part of the project area, it was concluded that the study should concentrate mainly upon determining losses due to insects since they appeared to be an important cause of grain loss, at least in the threshed grain stored inside the house. At a later stage it was felt that the significance of loss due to rodents had been underestimated and apparently serious losses were noted in some households. It was therefore decided that observations on rodent activity in the sample households should be recorded and a quantification of rodent losses attempted.

The preliminary survey carried out in early May confirmed that maize was a major crop in the area and that loss due to insects in storage was a serious problem. However, a study of the minor wheat crop was considered worthwhile since it would enable difficulties likely to be encountered in the main study of maize to be assessed, and at the same time would provide a good opportunity for field investigators to gain essential experience. As the project team gained experience it became evident that a limited study of losses occurring during the storage of paddy, another important crop in the region, would be possible. The maize study began in July 1979, and field work continued until the end of June 1980. Paddy was harvested in November and was stored within 2 - 3 weeks. Sampling in four panchayats began at this time and continued until the end of June, by which time most stores had been emptied, and only small amounts of grain remained.

The field investigators began their survey work by completing questionnaires giving background information for each sample household, including crops grown, pre-storage practices, storage structures, etc. A second questionnaire describing the sample store and crop stored was completed when the first grain sample was collected, and a third brief questionnaire and report form was completed at each sampling occasion (*see* Appendices 2, 3 and 4). The first wheat sample was usually collected at the time that the first questionnaire was completed.

In estimating the true total loss during storage it is important to relate losses to the pattern of grain consumption. This can be achieved by regularly withdrawing a sample of grain from the store as if for consumption, recording the quantities of grain removed by the householder between visits, and applying the loss (determined by analysis of the monthly samples) to the quantities removed each month (Adams, 1976). It was therefore proposed that the field investigators should remove approximately 1 kg of grain or ten maize cobs from the store for analysis at each visit. However this was not always easy to achieve. Entry into the room where grain was stored was often forbidden to strangers because of traditional beliefs in a household god. In these cases the investigators had to rely on a member of the household to draw a sample in the same fashion and from the same place each month. Whenever possible, the same member of the household was asked to collect the sample each month, but there was no guarantee that the sample would be removed from the quantity of grain which was currently being withdrawn for consumption. This was not such a problem with maize as many farmers stored their maize cobs on platforms (thangros) outside the house or hung their cobs in bunches under the eaves. Wheat and paddy is often stored in several containers and grain may be withdrawn from any one at any time and a container may not necessarily be emptied before the grain is removed from another. It was therefore necessary to obtain an estimate of the total quantity of grain stored by a household rather than the quantity in a single sample store. Sampling continued until all the grain had been removed and so the loss estimates obtained were losses per household rather than losses by store type.

Farmers were given milled rice in exchange for all grain samples collected. It was decided to give rice because it could not be returned to the sampled store and secondly, since rice is a valued commodity, this gesture helped to maintain a good relationship with the farmers. Samples of sound grain (after analysis) were sold at a subsidised price for consumption through the PAC stores and so part of the cost of the samples was recorded.

The quantities of grain in store were usually assessed visually by the field investigators but where entry to the house was prohibited, farmers were asked how much grain they had stored initially, how much they had removed since the last sample was collected, and how much remained. The figures reported were compared with the records from the previous months and any discrepancies questioned.

All grain quantities were reported in terms of the local standard volumetric measure used for measuring most commodities in the hills and understood by both the farmers and the field investigators. Grain could not be weighed in and out of store because: (i) the survey assistants would only meet the farmers once a month and could not be present on every occasion that grain was removed; (ii) access to the store room was not always permitted; and (iii) balances for weighing grain could not easily be transported in the hills.

The estimates of loss determined by analysis of the monthly samples were applied to the quantities of grain removed and expressed as a percentage of the total quantity originally stored. These monthly loss figures were then summed to give an estimate of the total loss according to the method described by Adams (1976). The field investigators had to return to PAC with their samples for analysis and so a basic four-week routine was established as follows:

Weeks 1 and 3	Weeks 2 and 4	
Fri/Sat/Sun/Mon/Tues/Wed/Thurs	*Fri/Sat/Sun/Mon*	*Tues/Wed/Thurs*
Travelling to and from the field and collecting data and samples	At PAC for laboratory work	Leave

The first seven days were spent travelling to and from the panchayat and collecting data and samples from half the selected households. This period could be extended for one or two days if the work load in that period was very high, or, as in the case of the panchayat furthest from PAC, there was insufficient time to complete the sampling after two days travelling. On arrival at PAC the samples were immediately examined by the field investigators under the direction of the project supervisors. Information sheets were completed and supplies for the next period in the panchayats were issued. On completion of the work at PAC the investigators were given leave until they were due to return to the field. Each investigator was entitled to 1½ free days per week and it was considered more appropriate to take time off after the work was completed at PAC. The investigators were expected to be travelling to and from and working in the panchayat for the following full seven days. On returning to the panchayat for the second period of seven days in the four-weekly routine, the second half of the selected households were visited.

The routine, which worked well throughout the study, was disturbed during the main religious festival of Desai (which lasted for approximately one week at the end of September) when the sampling of one-half of the households was delayed for one week and samples from all farmers were collected during one period in the panchayat after Desai. Towards the end of the survey, when very few farmers in some areas were still storing grain, the two sampling periods were combined. At this point, half the farmers were sampled after two weeks and thereafter every four weeks.

ESTIMATION OF LOSS

Insects

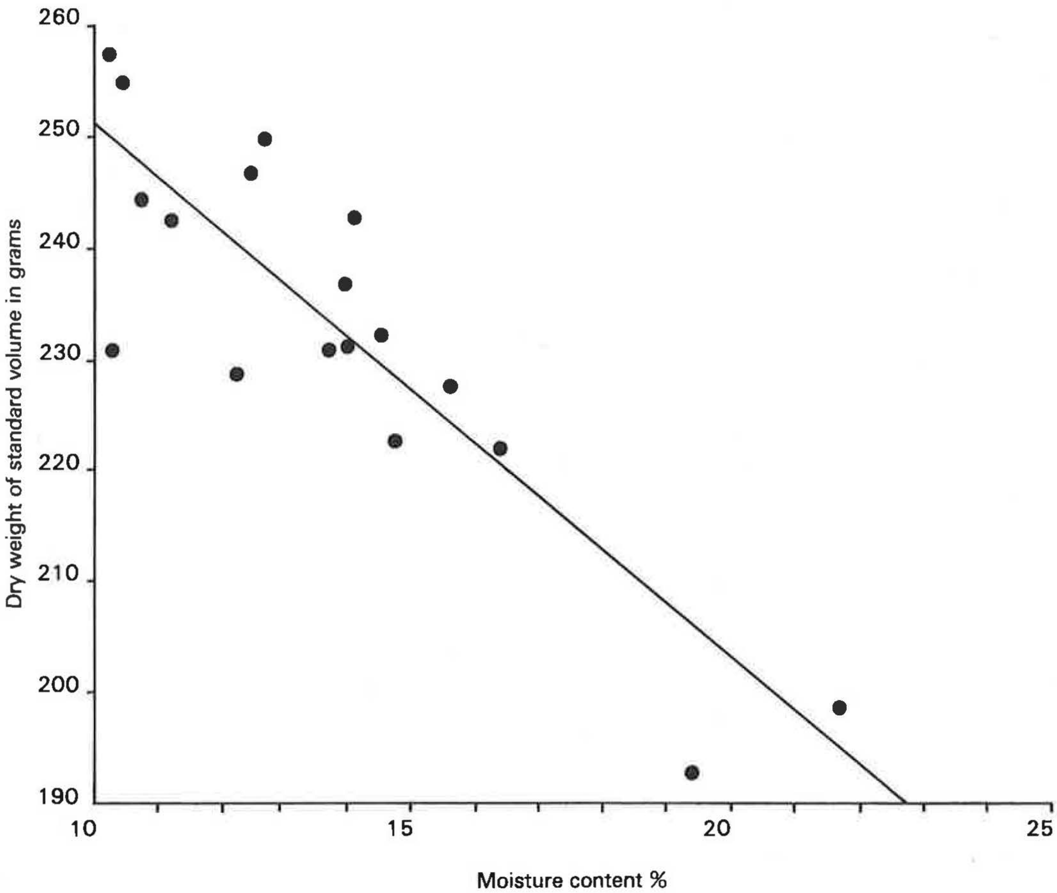
Wheat

In the survey of wheat losses, only a small number of households were studied and it was possible to return all grain samples to PAC for analysis. Losses due to insects were assessed by following the changes in the dry weight of a standard volume of grain. The method, described in detail by Adams and Schulten in *Post-harvest grain loss assessment methods* compiled by Harris and Lindblad (1978), recommends the use of a graph to predict the dry weight of an undamaged sample of grain at a range of moisture contents, since this dry weight is known to vary with changes in moisture content. Ideally a baseline graph should be prepared for each store being studied, since the standard volume weight (SVW) of a grain crop will be affected by other factors such as variety, growing conditions, climate, etc., as well as by moisture content. However, preparation of individual baseline graphs was impracticable, because of the limited laboratory facilities, the time needed to undertake the work and the difficulty of transporting to PAC the large initial samples required (a 5 kg sample is recommended) for the laboratory work. It was therefore decided to prepare only two baseline graphs (one for each of two distinct groups of wheat varieties, i.e. 'traditional' and 'improved') using aggregate data from the first samples collected. The baseline graphs showing the relationship between standard volume dry weight and moisture content for traditional and improved varieties are shown in Figures 2 and 3. When assessing the loss in a sample of wheat the moisture content was determined and the SVW measured. The weight, corrected to zero moisture content, was then compared with the predicted dry weight of the standard volume at the measured moisture content, the difference being the loss due to insect damage.

Maize

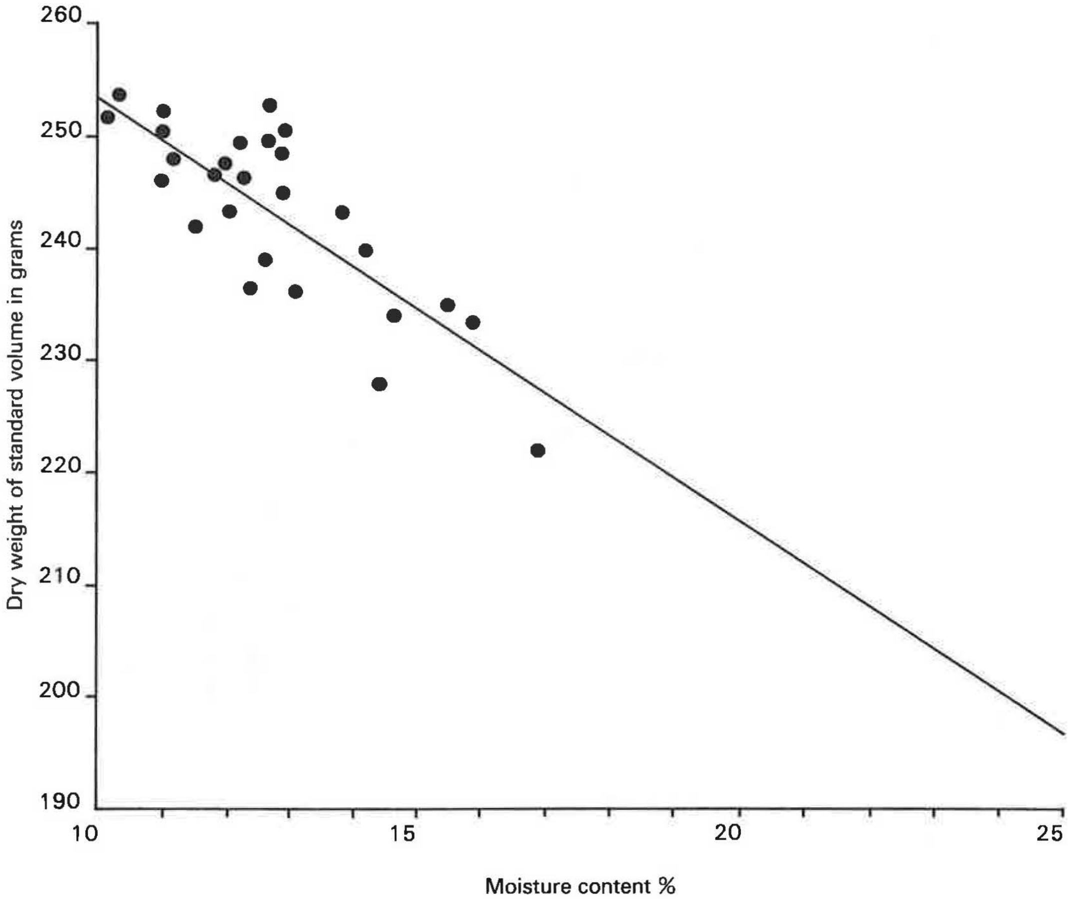
The investigation of wheat losses highlighted the problems of undertaking an intensive sampling programme and it became obvious that such a programme would not be

Figure 2
Wheat: Traditional varieties. Effect of grain moisture content on dry weight of standard volume



possible in the main study of maize because of the difficulties in transporting 200 samples per month to PAC and the length of time required to complete the analysis. It was not possible to fumigate grain samples before transferring them to PAC and it was felt that if long delays occurred between sample collection and sample analysis the samples would bear little relation to the condition of the grain at the time of sampling, especially if insect infestation was heavy. In fact, this was never a serious problem since it was decided that the field investigators should return to PAC twice each month. Nevertheless, a simpler method of sample analysis which could be undertaken in the field by the investigators seemed more appropriate in this study. Losses in maize were therefore calculated from an assessment of the percentage damage in a sample of ten cobs. The method referred to by Adams and Schulten in *Post-harvest grain loss assessment methods* compiled by Harris and Lindblad (1978), as the 'converted percentage damage method' involves the conversion of damage to weight loss by the application of a predetermined factor. A laboratory investigation to establish the relationship between percentage damage was performed on grain samples collected from fifty households, ten per panchayat. A conversion factor of 6.2 was used throughout the study, i.e. percentage of damaged grains in a sample was divided by this figure. The method of establishing the relationship between percentage damage and weight loss involves separating damaged and undamaged grains in a sample, and counting and weighing the fractions. The method assumes that insects choose grains at random which may not be true. It also does not account for hidden infestation because grains containing such infestation are classed as undamaged. Both these factors cause misleading results at low levels of infestation. At very high levels of infestation misleading results may occur because of multiple infestation especially in large grains. In an attempt to overcome the errors which might result at low levels of infestation, the conversion factor was determined using samples of grain which contained between 10% and 20% damaged grain. The problem of multiple infestation was overcome by instructing the field

Figure 3
Wheat: Improved varieties. Effect of grain moisture content on dry weight of standard volume



investigators to count the number of insect emergence holes rather than the number of damaged grains, but in practice multiple infestation was extremely rare.

Separate samples from the fifty households mentioned above were returned to PAC each month and losses assessed by the SVW method. These results were used as a cross-check of the field estimates obtained from percentage damage counts. Results were obtained from forty-four households. The losses calculated by the two methods agreed closely although the estimates obtained by the SVW method were slightly higher (*see* Table 3).

In applying the SVW method, allowance had to be made for the effect of moisture content on the standard volume dry weight and a baseline graph was prepared. It was possible to use a single graph (*see* Figure 4) since no significant difference was found between the standard volume/moisture content relationships of maize from the five panchayats.

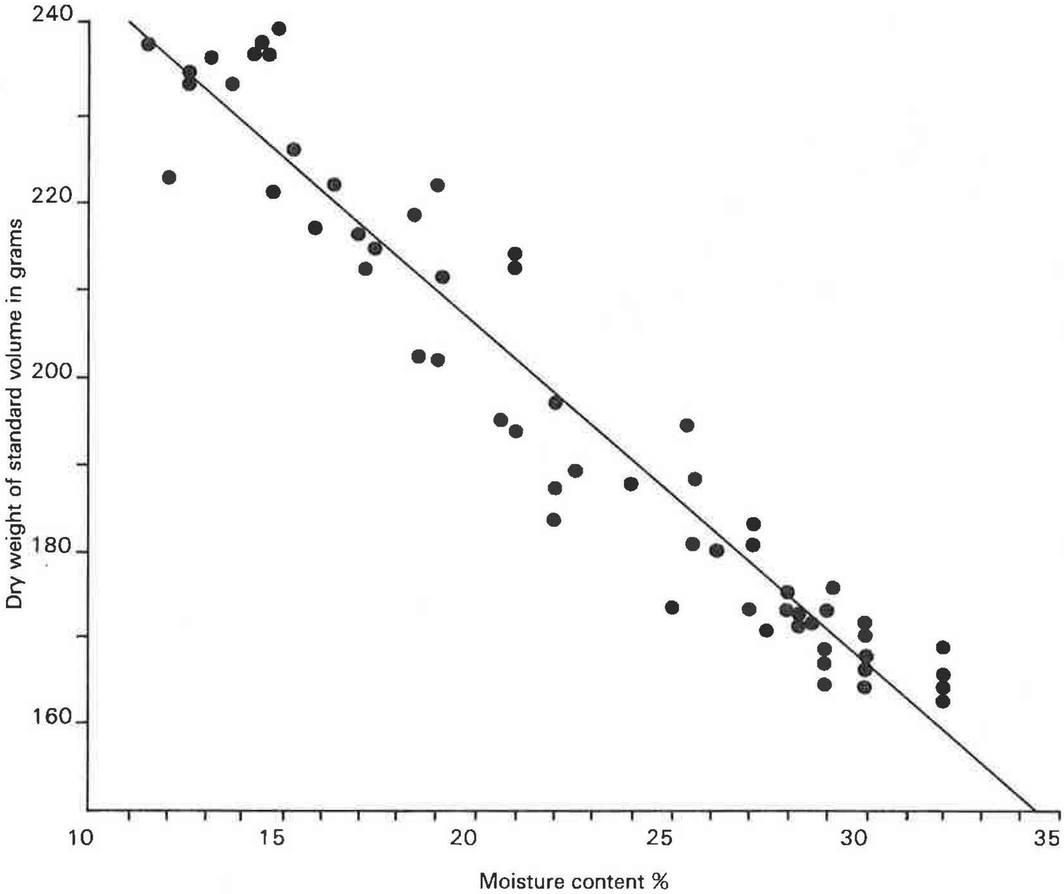
Table 3

Percentage weight loss due to insect infestation in maize using two methods of assessment

Method of assessment	Storage period in months					
	1–2	3–4	5–6	7–8	9–10	10+
Standard Volume	0.41	1.20	1.00	1.87	0.85	0.78
± SD[1]	0.32	0.91	0.82	1.80	0.72	0.70
Count and weigh	0.13	0.70	0.77	1.04	0.52	0.60
± SD[1]	0.19	0.64	0.46	1.26	0.45	0.42

Note: [1] Standard deviation.

Figure 4
Maize: Effect of grain moisture content on dry weight of standard volume



Paddy

Insect losses were assessed from samples returned to PAC, using the SVW method. Baseline graphs to take account of the effects of moisture content on the dry weight of a standard volume were attempted. Since the paddy varieties were traditional to each panchayat, it was considered that one graph per panchayat would suffice. However, the variation in bulk density between traditional varieties, even within a panchayat, was so great that it made it impossible to use aggregate data to produce a baseline graph.

The degree of variation in the bulk density of paddy was far greater than for wheat or maize. It has been mentioned that the bulk density of grain is affected by many factors and in the case of paddy in this study one or more of the following factors may have been responsible for the variation:

1 The farmers traditionally select and store their seed from their own production and so it is possible that a wide range of distinct genotypes, exhibiting a wide range of bulk densities each peculiar to individual farms, might be produced.

2 The degree of filling out of the rice grain is determined during the last few weeks of growth. The time of harvesting in relation to maturity would therefore have a significant effect on the size of the rice grains and consequently the bulk density. The period of harvesting in the project area extended over a period of 4 - 5 weeks and undoubtedly some farmers harvested early, before the rice grain was completely filled. Furthermore, harvesting was interrupted by a period of rain and this may have provided a period of extra growth for that part of the crop remaining in the field with the result that one distinct variety from one field may have shown two widely different bulk densities.

3 The nature of the land on which the crop is grown is likely to have an effect on the bulk density. In the region under study where the crops are grown on sloping fields or on terraces on steep slopes a certain amount of leaching of nutrients from the higher to the lower part of the field occurs and so crops with widely differing bulk densities may be expected.

4 Paddy is frequently stored in a number of small vessels rather that in one large storage container and each vessel may be filled with grain from separate parts of the 'field', each sample differing in bulk density. When the grain is stored in a large container a certain amount of mixing of the grain takes place and the amount of variation in bulk densities of the crop stored by a household would be reduced.

The situation was clearly one which demanded a baseline graph for each individual store, but this was quite impracticable because of the amount of laboratory work involved. It was therefore decided that the standard volume dry weights of the initial samples from each store would be used as baselines from which to measure losses. This procedure proved to be adequate although some inconsistencies in the measurements of bulk density were found and apparent weight gains were recorded. Closer examination of the results and field observations revealed that these inconsistencies often occurred where paddy was stored in several vessels. The samples may not have been strictly comparable with the first samples because of varietal differences or bulk density variations within a variety. In a few cases the first samples were collected a week or two after the grain had been stored and after some rodent damage had occurred. The presence of rodent-damaged grains, mostly hollowed husks, resulted in a lower than normal SVW.

Rodents

Losses caused by rodents are difficult to assess directly because many grains are completely removed from the store. Estimates can be obtained by weighing grain into and out of store throughout the season and allowing for the loss due to insects. However, the remaining 'loss', which is then usually attributed to rodents, may be due in part to other causes such as birds.

In this project it was not possible to weigh grain into and out of store and so no measurements of rodent losses in wheat and paddy could be made, but an estimation of rodent losses in stored maize was attempted. Each monthly sample of 10 cobs selected for insect damage counts was first examined for signs of rodent damage i.e. gnawed grains or areas of the cobs from which grains had been removed. The percentage damage in each cob was estimated and the average taken as the weight loss in the sample. This weight loss was applied to the quantity of grain removed since the previous sample was collected, to obtain the monthly loss in exactly the same way as insect losses were calculated. It was assumed that the percentage damage was equal to the weight loss since even the gnawed grains which remained on the cob would be discarded when the cobs were shelled before consumption. This method of assessing rodent loss may, however, produce an over-estimate or an under-estimate of weight loss depending upon the part of the cob which is damaged. The method assumes that all grains are of equal weight but if the damage is restricted to the smaller grains located at the end of the cob the true weight loss will be lower than the estimate. Similarly if the larger grains in the centre of the cob are damaged the true loss will be greater. The method is also subject to errors in estimating the percentage damage. A short investigation was therefore conducted to determine the likely error in the method. Rodent damage was simulated in a number of maize cobs by removing grains. Field investigators were then asked to assess the percentage damage (and weight loss) and the results compared with the true weight loss obtained by weighing the 'damaged' (removed) grains and the total quantity of grain shelled from each cob.

It was found that the percentage damage per sample was on average underestimated by 2.5%. Consequently the total recorded loss due to rodents was raised by 0.4%.

Moulds

In assessing loss due to mould, measurements were made of the amount of damaged grain which would normally be rejected by the house hold as inedible. No wheat or paddy was actually rejected. The growth of moulds, however, reduces the bulk density of the grain and so the estimates of insect loss for wheat and paddy (where losses were measured by the SVW method) also include an element of loss due to mould. This loss is likely to be so small that it can be ignored.

Mould damage in stored maize cobs was more severe than in wheat or paddy. The weight loss was estimated by assessing the percentage of damaged grains (by the same method used to assess rodent losses) and converting this to a whole grain equivalent.

STORAGE LOSSES

Wheat

The study of the wheat crop, which is generally stored for a short 2- or 3-month period, was planned as a pilot exercise and was not expected to provide good estimates of loss. Nevertheless, the field investigators quickly established a good rapport with the sample farmers and good co-operation was achieved. The survey was conducted in the four important wheat producing panchayats and satisfactory results were obtained from 41 of the 49 sample households originally selected. In two panchayats some wheat was stored early, 3–4 weeks before the survey began, and it is possible that the results from these panchayats (15 households) slightly underestimate the loss, since the loss which might have occurred in the first few weeks of storage will not have been included.

The results of the survey of losses in wheat are summarised in Table 4. The estimate of weight loss due to insects (mainly *Sitophilus* spp.) was 2.4 ± 1.9% during an average storage period of 3 months. There was no overall difference in the levels of loss recorded in each of the four panchayats but variability in length of storage period, types and sizes of storage containers, quantities of grain stored, and standard of store hygiene was considerable. The sample size was too small to enable an investigation of the effect of these variables on the levels of loss. Losses due to insects are expected to vary with altitude – insect activity decreasing at high altitudes. However this pattern was not apparent from the results (*see* Table 5)

Table 4

Weight loss due to insect damage in wheat expressed as a percentage of the total quantity originally stored

Panchayat	No. of households	Average storage period in months	% weight loss
Tankuwa	10	2.9	2.2
Murtidhunga	12	3.4	1.7
Srijung	18	3.0	2.9
Marek Katahare	1	3.0	1.2
All households	41	3.0	2.4 ± 1.9

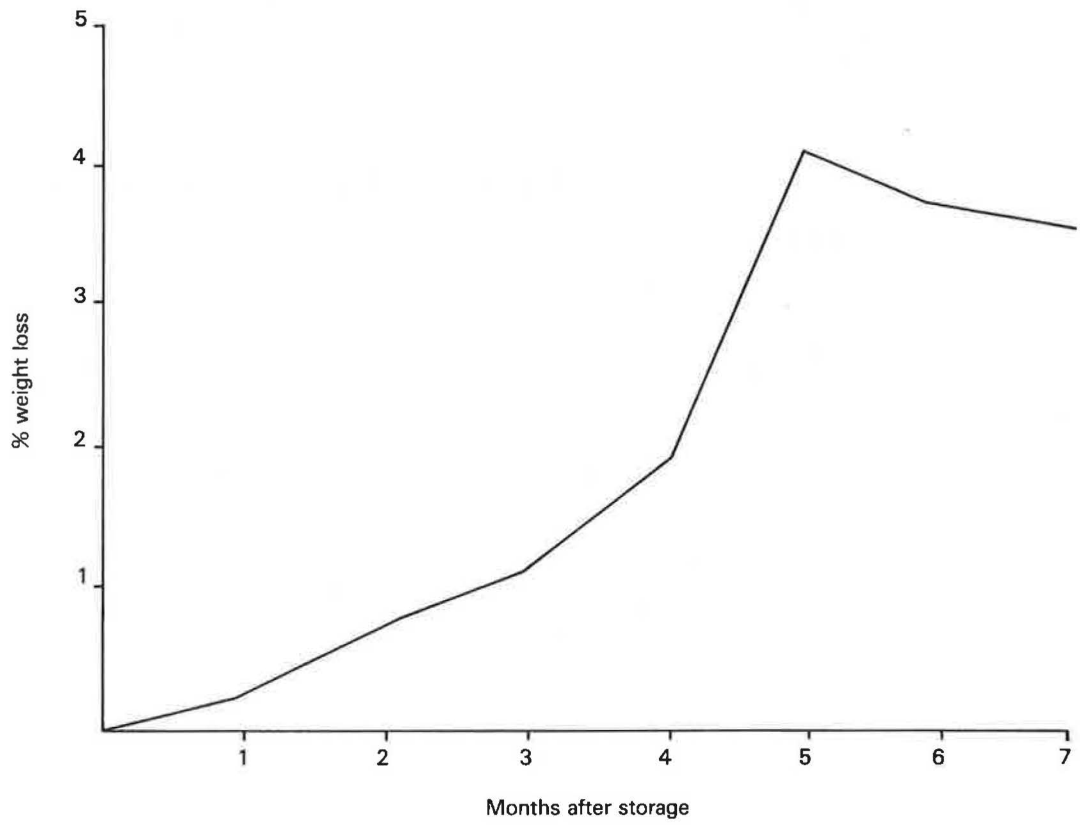
Table 5

Percentage weight loss due to insect damage in wheat stored at different altitudes

Altitude in metres	No. of households	Average storage period in months	% weight loss
600–1,200	13	2.9	2.1
1,200–1,800	19	2.7	2.0
Above 1,800	9	3.8	3.5

probably because of the variations in the factors affecting losses mentioned above. The higher loss at the high altitude (3.5%) may be due to the fact that most of the wheat stored at this altitude was stored as unthreshed ears which are likely to be more vulnerable to insect attack. Furthermore the storage period at the high altitudes was on average longer and it was shown that losses increased with the length of storage (*see* Figure 5).

Figure 5
Average percentage weight loss in wheat due to insect infestation



Improved varieties of grains are often reported to be more susceptible to insect attack than the old traditional varieties. The wheat stored in the project area was said by many farmers to be liable to heavy insect attack but the results of the study do not establish this (*see* Table 6). The traditional varieties of wheat were often stored as unthreshed ears and therefore may be vulnerable to insect attack. The improved wheat in the project area was stored as threshed grain but it is known that in some parts of the Kosi Zone improved wheat varieties are also stored as unthreshed ears. In these situations higher insect losses might be expected.

Table 6
Percentage weight loss due to insect damage in traditional and improved varieties of wheat

Variety	No. of households	Average storage period in months	% weight loss
Traditional	17	2.6	3.0
Improved	24	3.3	2.0

Maize

Insects

In the survey of losses in maize, 177 of the original 200 selected samples stores provided results which could be used in the final analysis. The data from the remaining 23 stores were incomplete because farmers abandoned their land and migrated because of the drought, or refused to allow the field investigators to collect samples from their stores.

The method of sample analysis allowed the categorisation of loss by cause namely insects, rodents and mould. The final estimate of weight loss for an average storage period of 6.1 months was 5.7 ± 3.2%. The results of the survey of maize losses are summarised in Table 7 and losses due to insects, analysed in relation to altitude and period of storage, are summarised in Table 8.

Table 7

Weight loss in maize expressed as a percentage of the total quantity originally stored

Average storage period in months	% weight loss			
	Insects	Rodents	Moulds	Total
6.1	0.6	3.7	1.4	5.7 ± 3.2

Table 8

Percentage weight loss due to insect damage in maize in relation to altitude and storage period

Storage period in months	No. of farmers at different altitudes			% weight loss at different altitudes		
	600-1,200 m	1,200-1,800 m	Above 1,800 m	600-1,200 m	1,200-1,800 m	Above 1,800 m
1-4	53	18	–	0.3	0.4	–
5-8	14	17	14	0.7	1.0	0.1
9+	10	24	27	1.1	1.4	0.4

The results do not fully confirm earlier observations and expectations. The level of loss, particularly at the lower altitudes, is perhaps less than might be expected since during the period of the study the crop yields were seriously affected by drought. As a consequence maize at the lower altitudes was quickly consumed, and in fact 68% of the sample households in this grouping finished their maize within four months. (The difference in consumption patterns at the different altitudes is shown in Figure 6). The level of loss at the low altitude may be indicative of the lower moisture content of the grain at the time of storing in this exceptionally dry year (*see* Table 9).

Not all areas were so seriously affected by drought and the losses due to insect infestation in these areas were higher. As expected the quantities of maize stored and the average storage period were greater than in the drought affected areas (*see* Tables 10 and 11).

Table 9

Average moisture content (%) of maize at time of storing

Altitude in metres	Moisture content
600-1,200	22.7
1,200-1,800	28.2
Above 1,800	27.8

Figure 6
Percentage of maize remaining in store at different altitudes

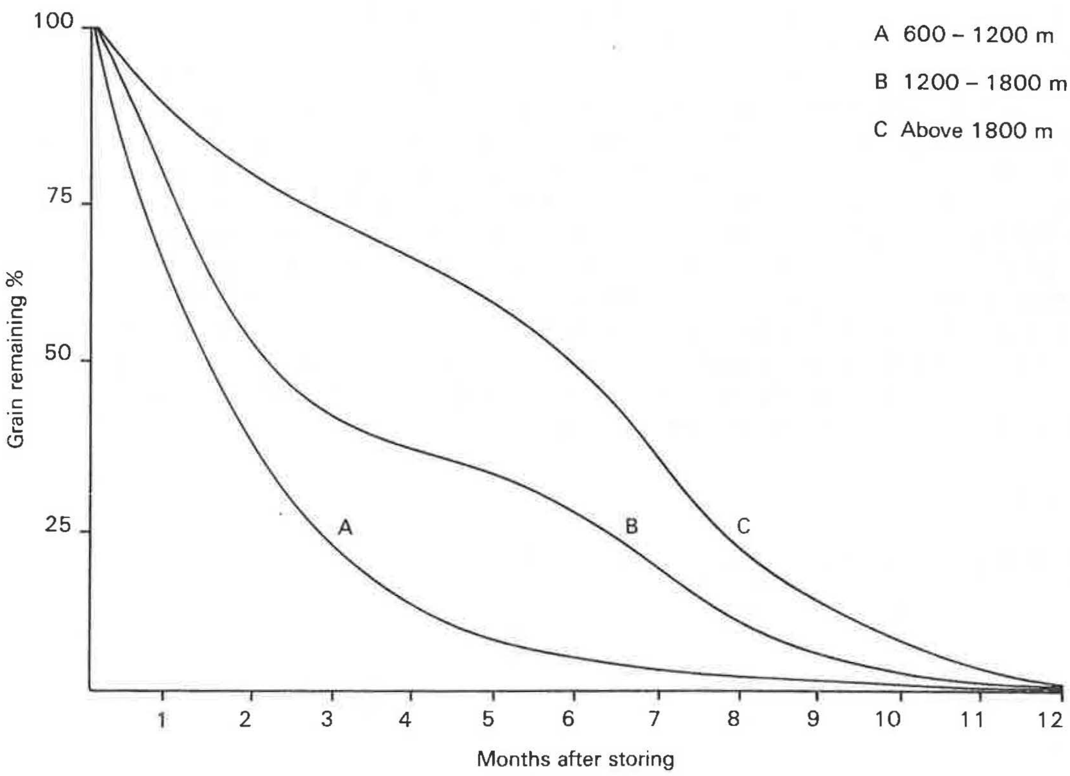


Table 10

Effect of drought on percentage weight loss due to insect infestation in maize at low altitude (600-1,200 m)

	Storage period in months		
	1-4	5-8	9+
Drought affected panchayats	0.2	0.5	0.5
Non-affected panchayats	–	0.9	1.5

Table 11

Effect of drought on storage period, quantity stored and percentage weight loss due to insects

	Average storage period in months	Average quantity stored in kg	% weight loss
Drought affected panchayats	3.0	153	0.3
Non-affected panchayats	6.5	436	1.2

In normal years the quantity of maize stored by households lying between 600 and 1,200 m is expected to be greater and so even the figure of 1.2% loss due to insects may be an underestimate.

Rodents

Estimates of rodent losses were grouped by altitude and by period of storage (*see* Table 12) but no significant differences were found except for maize stored for 1-4 months at the altitude grouping of 1,200 - 1,800 m.

The figures for loss at the lower altitude (600 - 1,200 m) especially for the 1-4 month storage period are likely to be overestimates. Maize was stored earliest at the lower altitudes and therefore was the first grain to be sampled. It is suspected that the field investigators had some difficulty in understanding and applying the methodology for assessing rodent losses and some over-estimates may have been recorded. Some grain removed early from store was missed and it is possible that the estimates of loss from later samples were applied to these early removals when in fact no rodent damage had occurred. This would have the effect of increasing the final figure for loss due to rodents. However, the survey was undertaken in an abnormally dry year when more grain than usual was stored inside the house (where rodent infestations were noted to be serious). An analysis of rodent losses in relation to type of storage structure was undertaken and this clearly demonstrated that higher losses occurred when the maize was stored inside the house (*see* Table 13). It was not possible to include all rodent loss results in this analysis by storage structure since some of the field investigators' observations were poorly recorded, making it difficult to decide exactly how the maize had been stored. In some households more than one method of storage was used.

Table 12

Percentage weight loss due to rodents in maize

Altitude in metres	Storage period in months		
	1–4	5–8	9+
600–1,200	4.4	4.6	5.2
1,200–1,800	0.1	3.6	4.3
Above 1,800	–	4.0	3.5

Table 13

Percentage weight loss due to rodents in maize in relation to storage structure

Storage structure	No. of households	% weight loss
Pile inside house	23	13.3
Eaves of house	28	5.9
Thangro	29	3.9

Moulds

Loss due to mould damage was estimated by assessing the percentage of damaged grains that would be rejected as unfit for consumption and converting this to a whole grain equivalent. The method was the same as that used for assessing rodent loss and therefore subject to the same errors. Work carried out at PAC demonstrated that at harvest time, 10-13% of maize cobs were seriously affected by pre-harvest fungal damage. It is therefore probable that the storage loss due to mould recorded in this survey includes some loss due to pre-harvest damage. The results of the estimation of loss due to mould are summarised in Table 14.

During the period of this survey cobs were stored in piles inside the house for much longer than usual and in some cases were never removed to thangros. Under these circumstances severe mould damage resulting from storage of high moisture content cobs seems inevitable. However the estimates of loss at the lower altitude (600 - 1,200 m) may be over-estimates because the problems encountered in applying the methodology to assess rodent loss apply equally to the assessment to loss due to mould damage.

Table 14

Percentage weight loss in maize due to mould damage

Altitude in metres	Storage period in months		
	1–4	5–8	9+
600–1,200	1.0	3.5	2.6
1,200–1,800	1.0	1.5	0.5
Above 1,800	–	1.3	1.1

Paddy

The study of losses in paddy was conducted in four panchayats and 76 households were sampled initially although results from only 53 were included in the final analysis. The number of sample households was restricted because the major effort had to be devoted to the main study of losses in maize. Sampling continued until the end of June 1980 by which time most stores were empty, however a few stores had to be abandoned because it had been decided to terminate the field work by the end of June. The absence of results from the few remaining stores, which in any case contained only small amounts of grain at the time, is not likely to seriously affect the overall estimates of loss.

The average weight loss due to insects (mainly *Sitotroga cerealella* and *Sitophilus* spp.) was 3.4± 2.2% over an average storage period of 7.8 months. The sample households, selected from the four major rice producing panchayats, were all situated between 600 and 1,800 m and no significant difference was found in the level of loss in the two different altitude groupings (600 - 1,200 m and 1,200 - 1,800 m).

The difficulties of obtaining estimates of losses due to insects in stored paddy have been discussed earlier (*see* p. 15), and it is possible that because of these difficulties the figure is a slight over-estimate. Nevertheless the loss is much lower than previously suspected.

Examples of high loss (10%) were recorded although only where grain was stored in a number of small vessels, a situation in which a heavily infested vessel might have easily been overlooked by the householder.

This study demonstrated that in general little insect damage occurs before May although at the lower altitudes damage by *Sitotroga cerealella* was evident as early as March. The paddy crop is stored in November/December and for the first few months of storage insect activity is expected to be low because of the low winter temperatures.

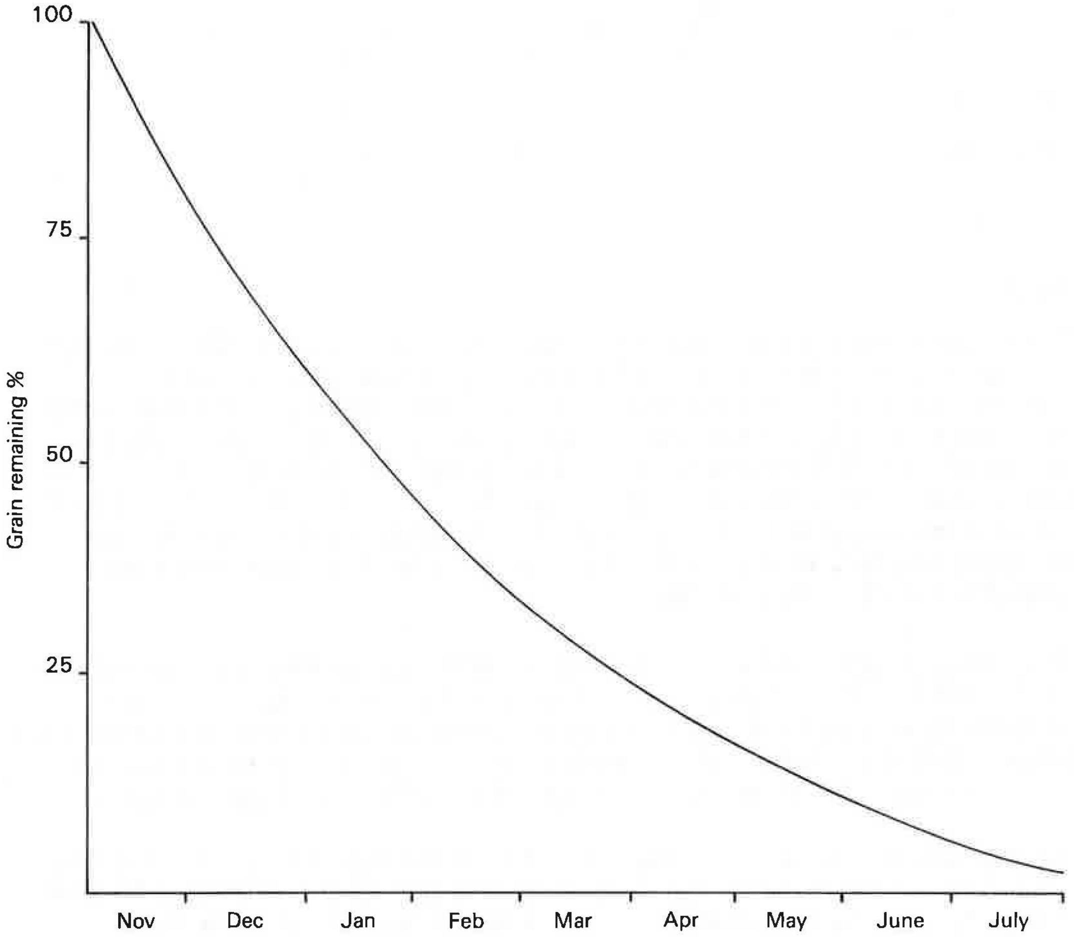
It was found that during this cold period approximately 60% of the crop was consumed and by the time insect activity is increasing rapidly (April-May) only about 25% of the grain remains in store (*see* Figure 7).

It was not possible to estimate losses caused by rodents although from observations of storage structures rodents were considered to be damaging and spoiling significant quantities of grain. In many samples (approximately 25%) a high proportion of rodent-damaged grain in the form of empty husks and broken rice grains was recorded. No loss due to mould damage was recorded. Despite the initially high moisture contents (22%), the paddy appeared to dry quickly to 15-16% without significant mould damage occurring.

DISCUSSION AND CONCLUSIONS

This study has clearly demonstrated that farm level storage losses in the Eastern Hills of Nepal are of the order of 5% which is considerably lower than previously reports

Figure 7
Percentage of paddy remaining in store



(10 - 30%). The low storage loss due to insects recorded for maize (0.6%) is undoubtedly due to the effect of the drought on crop yields and the subsequent short storage period. Under normal conditions the period of storage would be expected to be much longer and the risk of damage by insects could be greater. The evidence from areas unaffected by the drought suggests that the resulting weight loss in normal years may be twice as great as that recorded in this study. During the course of the study farmers often reported that insect damage occurred immediately after harvest and continued until the colder winter months. Further insect activity would begin in the following April and it would increase with the onset of the monsoon, continuing until all the maize was consumed. However, during the period of the study many farmers especially those growing maize at the lower altitudes had consumed their maize within four months of harvest. Nevertheless there is evidence to show that even when larger quantities of maize are stored for longer periods the loss due to insects is low (1.2%).

Rodents are clearly a problem inside the house where they may cause significant weight losses in stored grain. It is debatable, however, whether the weight loss in maize due to rodents would be greater in years of plenty since the proportion of the total harvested crop stored inside the house would be less than in the period under study. Generally the maize stored on the thangros was less susceptible to attack by rodents, but it is of course vulnerable to attack by birds. Although no measurements of this loss could be made, birds did not appear to be a serious problem.

Mould damage commonly occurs on the maize cobs in the field before harvest and further damage may occur during storage particularly if piles of wet cobs are stored inside the house for long periods. When maize is harvested after the rains and stored almost immediately on thangros, as it is at the higher altitudes, loss due to mould is less severe.

The main aim of this project was to establish estimates of loss for the major crop in the region, namely maize, and the studies of wheat and paddy can only be regarded as supplementary studies. Nevertheless estimates of loss due to insect infestation for both these crops have been possible and although there may be some doubt about their reliability because of the small sample size and restricted areas of study they do give a better indication of the level of loss than has hitherto been available.

The study has enabled a better understanding of the traditional storage practices in the Eastern Hills and although the level of loss determined does not justify a major loss reduction programme, storage extension cannot be dismissed as unimportant. The potential exists for serious loss caused by rodents and insects in the traditional farming system.

It is common to regard the hill areas of Nepal as being deficient in food and it was evident from this study that procurement of sufficient food, even in good years, must be difficult for a large number of households. A reduction of the storage losses, even the small losses reported here, would go some way to alleviating the problem.

There is an obvious need to improve store management and hygiene to reduce insect infestation problems. The small quantities of grain and grain residues remaining in or near the storage containers from one season to the next provide harbourage for insects which may infest newly harvested crops. Rodents are a serious problem particularly where maize cobs are strewn over the floor of the house but damage is apparently less severe when the cobs are neatly stacked. This point perhaps needs further verification, but farmers should still be encouraged to stack their maize cobs, if only as a step towards improving the standard of hygiene and reducing the availability to the gnawing action of rodents.

Some traditional containers are often inadequate for storage. For example wheat and paddy are sometimes stored in a large number of small vessels making stock management difficult and increasing the risk that a quantity of infested grain may remain undetected for a long time. This situation may have arisen only recently with the wider introduction of wheat and the double cropping of maize and paddy. The farmer has sufficient large storage structures (dhikutis and bhakaris) for his main crop, but when the additional and often small harvests, which do not justify the construction of extra structures, are brought in, smaller household vessels have to serve as grain stores if the crops are to be segregated. The larger traditional stores such as the dhikutis and bhakaris can be simply modified to exclude rodents. For example, the basket stores (bhakari) in some areas are provided with woven basket lids which effectively exclude rodents and this idea seems worth pursuing. The mud bins (dhikuti) are rarely provided with a lid but closed dhikutis are not unknown. Here again the use of a lid would seem an appropriate measure to adopt to restrict rodent damage to the stored grain.

Maize stored on thangros suffers some damage by rodents but the evidence suggests that the damage is only severe when the thangro is built close to the house and rodent access, particularly from the upper floors of the house, is easy. A relocation of the thangro at least 2 m from the house may be all that is required to reduce losses. This should not be difficult to achieve since in many areas thangros are dismantled at the end of the storage season and rebuilt for the new crop. Further investigation of the rodent problem on thangros is necessary to establish whether there is a need to fit rat guards to the legs of the structure in line with general recommendations made elsewhere for the proofing of stores against rodents.

The development of entirely new methods of storage for use at the farm level cannot be recommended at this time; instead the basis of the extension message should be the adoption, by all farmers, of better designs of traditional storage containers and their careful maintenance and correct use. However, any changes in farming practices such as the cultivation of new varieties (which may be more susceptible to insect attack), or the increase in the amount of grain to be retained on the farm, could lead to a significant increase in losses.

In the Eastern Hills of Nepal the efforts being made to increase production include the introduction of new improved varieties of crops which, based on the evidence from elsewhere, may lead to serious insect infestation problems in storage. This is particularly true for the wheat crop. Wheat, harvested in April/May is stored over all or part of the monsoon period, i.e. the period most favourable for insect development. The problems of insect infestation are not too serious at present but may be expected to increase as more wheat, and especially new varieties of wheat, are introduced. Indeed, some farmers are already aware that the new varieties of wheat are susceptible to insect attack and they frequently cite this as one reason why they prefer to sell the crop early if possible rather than retain it for consumption. It is therefore important that development programmes keep the situation under review and continue to include consideration of traditional conservation methods and their capabilities.

Insecticides and rodenticides are not commonly used to protect stored grain in the Eastern Hills although their use is increasing. The widespread use of pesticides, however, cannot be justified by the results of this study and emphasis must be placed on simple good housekeeping and hygiene practices to restrict rodent harbourages and access to grain and to avoid the carryover of grain from one season to the next. Grain fumigants are available in the local markets from time to time. However, use of fumigants is to be discouraged not simply because their use is not justified but because of the risks involved in fumigating household grain stores which cannot be sealed adequately.

It must, however, be recognised that under the present distribution system for agricultural inputs the availability of pesticides to rural farmers will increase. There is therefore a need to keep the situation under review and perhaps at a later stage to undertake a further study to establish the appropriateness of promoting pesticides for the protection of farm-stored grain.

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Appendices

APPENDIX 1

Budget — local costs May 1979–September 1980

		Costs in Nepal Rupees[2]	
A Capital expenditure			
Equipment[1]			
moisture meter		3,300	
SVW apparatus		560	
balance (capacity 0.5 kg x 0.1g)		840	
sieves		560	
	Total A		5,260
B Recurrent expenditure			
Salaries and wages			
1 VSO for 18 months at Rs 1,150 per month		20,700	
1 Agricultural Officer, Class 1 for 10 months at Rs 2,000 per month		20,000	
6 Survey Assistants: 4 for 14 months at Rs 550 per month		30,800	
2 for 10 months at Rs 550 per month		11,000	
			82,500
Staff travel and subsistence			
1 VSO for 180 days at Rs 35 per day		6,300	
1 Agricultural Officer, Class 1 for 100 days at Rs 35 per day		3,500	
6 Survey Assistants: 4 for 224 days at Rs 55 per day		49,280	
2 for 160 days at Rs 55 per day		17,600	
			76,680
Supplies			
sample labels: 10 boxes at Rs 62.50 per box		625	
plastic sample bags, 15 x 23 cm: 10 kg at Rs 39 per kg		390	
rice (exchanged for samples): 1,100 kg at Rs 3.50 per kg		3,850	
stationery		700	
books		500	
			6,065
	Total B		165,245
C Recovery of costs			
Resale of samples		1,000	
	Total C		1,000
Summary: total capital expenditure (A)		5,260	
total recurrent expenditure (B)		165,245	
		170,505	
less receipts from resale of samples (C)		1,000	
total cost		Rs 169,505	

Notes: (1) All equipment loaned to the project. Equipment costs are approximate
(2) Rate of exchange October 1980 Nepal Rupees 28 = £1 sterling

APPENDIX 2

Pakhribas Agricultural Centre—Dhankuta, Loss assessment survey
Questionnaire 1—General survey

1 Date....................................
2 Farmer's name ....
3 Code ....
4 Panchayat ....
   (a) Ward number ....
   (b) Zilla ....
5 Size of family
   (a) Adults   Male....... Female.......
   (b) Children (under 14)   Male....... Female.......
6 Size of farm
   (a) Total .... Ropani[1]
   (b) Khet .... Ropani
   (c) Bari .... Ropani
7 Storage structures

	Structure/Quantity				
	Structure 1	Structure 2	Structure 3	Structure 4	Total
(a) Dhikuti	...	...	...	...	...
(b) Bhakari	...	...	...	...	...
(c) Kota	...	...	...	...	...
(d) Thangro	...	...	...	...	...
(e) Baha (eaves)	...	...	...	...	...
(f) Other (tin, bag, etc.)	...	...	...	...	...

8 Losses
   (a) In your opinion how much is lost?.................................
   (b) In your opinion what is the most important cause of loss?...............
   ....
   (c) What is the damaged grain used for?...............................
      (i) Eaten ....
      (ii) Animal feed ....
      (iii) Discarded ....
9 Crop analysis

	Wheat	Maize		Rice	
		Bari	Khet	Main crop	Tauli
(a) Crop grown	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
(b) Varieties	a	a	a	a	a
	b	b	b	b	b
	c	c	c	c	c
(c) Area grown (Ropani)	a	a	a	a	a
	b	b	b	b	b
	c	c	c	c	c
(d) Total grown	...	...	...	...	...
(e) Date of sowing/transplanting	a	a	a	a	a
	b	b	b	b	b
	c	c	c	c	c
(f) Date of harvest	...	...	...	...	...
(g) Quantity stored					
(i) Grain	...	...	...	...	...
(ii) Seed	...	...	...	...	...
(iii) Sale	...	...	...	...	...
(iv) Others	...	...	...	...	...
(v) Total	...	...	...	...	...

10 How often is the grain removed from the store? ....
11 What quantity is removed each time?......................................

Note: (1) 1 Ropani = 500m^2 (approximately)

APPENDIX 3

Pakhribas Agricultural Centre—Dhankuta, Loss assessment survey
Questionnaire 2—Crop and store report

1 Date ....
2 Farmer's name ....
3 Code ....
4 Panchayat ....
   (a) Ward number ....
5 Crop ....
   (a) Variety ....
   (b) Area .... Ropani
6 Date of sowing ....
7 Date of harvest ....
8 Drying time after harvest ....
9 Drying place used .... Khet/Bari/House
10 Threshing time taken ....
11 Method of threshing ....
12 Date of storage ....
13 Storage structures

	Quantity	Use of grain
(a) Dhikuti	....	....
(b) Bhakari	....	....
(c) Kota	....	....
(d) Thangro	....	....
(e) Baha	....	....
(f) Other	....	....

14 Condition of store
   (a) Cleanliness .... Clean/Dirty
   (b) Presence of insects .... Observed/Unobserved
   (c) Rodent damage .... Observed/Unobserved
   (d) Loss prevention methods used
      (i) Insecticides .... Yes/No   Name ....
      (ii) Rodenticides .... Yes/No   Name ....
      (iii) Rat trap .... Yes/No
   (e) Use of local practices .... Yes/No

APPENDIX 4

Pakhribas Agricultural Centre—Dhankuta, Loss assessment survey
Questionnaire 3—Monthly sample report

1 Date ....
2 Farmer's name ....*
3 Code ....
4 Panchayat ....
   (a) Ward number ....
5 Crop ....
6 Storage ....

	Structure 1	Structure 2	Structure 3	Structure 4	Total
(a) Storage structures	....	....	....	....	....
(b) Initial quantity stored	....	....	....	....	....
(c) Quantity remaining	....	....	....	....	....
(d) Quantity removed since last visit	....	....	....	....	....

7 Grain use ....

8 Condition of store
- (a) Cleanliness .... Clean/Dirty
- (b) Bird damage.......................... Observed/Unobserved
- (c) Rodent damage .... Observed/Unobserved
- (d) Loss prevention methods used
  - (i) Insecticides ....Yes/No Name......................
  - (ii) Rodenticides ....Yes/No Name......................
  - (iii) Rat trap ....Yes/No

9 Cob damage
- (a) % damage (average of 10 cobs)
  - (i) Rodent damage ....%
  - (ii) Fungal damage ....%
- (b) Insect loss — crop analysis — maize
  - (i) Total no. of grains a b c
  - (ii) No. of sound grains
  - (iii) No. of damaged grains
  - (iv) % damaged grains
  - (v) Conversion factor
  - (vi) Weight loss ....
  - (vii) Average weight loss ....

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