FARM LEVEL STORAGE LOSSES IN EASTERN NEPAL

R A Boxall [1] and R Gillett [2]

[1] TDRI Storage Department, Slough, England.
[2] "The White House", Kirkmichael, Ayrshire, UK.
(Formerly c/o VSO Overseas; in Nepal)

Abstract

A study of farm level storage losses in the Eastern Hills of Nepal, between May 1979 and June 1980, in a year affected by drought, showed that farm level storage losses (approximately 5%) were lower than previously reported (10–30%). In these circumstances, programmes to reduce losses by introducing new storage structures and pesticides, even if practicable, were shown to be unjustifiable but the need for futher studies with particular regard to possible increases in production is indicated.

Introduction

The project was limited to a small area of the Kosi Zone in the Eastern Hills and concentrated upon maize, which is the major food crop of the area. A preliminary survey of a minor grain crop (wheat) was undertaken first so that technical and logistical difficulties likely to be experienced in the main study of maize losses could be assessed and to provide an opportunity for field investigators to gain essential experience in loss assessment techniques. As the main study progressed it became evident that a supplementary study of losses during the storage of paddy, another important crop in the area, would be possible and this was undertaken in the second half of the project. The year in which the project was conducted (May 1979 – June 1980) was an exceptionally dry one and the maize crop yields in some parts of the Eastern Hills were quite seriously affected by drought.

The project was based at the Pakhribas Agricultural Centre of the Gurkha Reintegration Scheme, located in the middle hills of the Kosi Zone of Nepal. The terrain in this area is deeply incised by two main rivers, the Aran and the Tamur, and their tributaries. The hill slopes are steep and the elevation varies from 270m to 2700m. The population lives in scattered, isolated households rather than in clearly defined villages but households are grouped into administrative areas (the village *panchayats*) which provided convenient sample units. The terrain posed serious problems of access and communication thus making survey work exceptionally difficult. The intensive pattern of sampling and sample analysis which had been employed in earlier farm-level storage loss assessment studies (Adams and Harman, 1977; Boxall et al, 1978) could not readily be applied in such a situation.

Five project areas *(panchayats)* were selected and six field investigators were appointed, one to each of the five areas and one who spent some time in each, helping the permanent investigator at peak sampling times or deputising for other investigators when they were sick or on leave. Areas were selected on the basis of previous survey data (Conlin and Falk, 1979) and excluded any that were more than 1-2 days walk from the survey centre at Pakhribas.

Harvesting and Storage. The wheat crop in the Eastern Hills is harvested in April and May and is stored for two or three months in a variety of containers ranging from small earthenware pots to large baskets or mud bins built inside the house. In some parts of the project area wheat was stored unthreshed, the bundles of ears being hung under the eaves of the house, or stored in baskets. The storage period for wheat extends into the monsoon period when conditions are favourable for storage insect pests.

Maize is regarded as the major crop in the Eastern Hills and is generally harvested between August and September although, in the valleys, harvesting may begin in July whilst, at high altitudes, it may not begin until October. Large quantities of maize cobs, equivalent to about 750 kg of shelled maize, may be stored for up to 12 months. The cobs, in sheath, are either stored on a wooden frame or platform *(thangro)* erected close to the house or they are hung under the house eaves. Cobs are also stored inside the house either in loose piles or in well constructed stacks in the upper floors, but usually only during the rains after which they are transferred to the *thangro.* During the period of the loss assessment survey more farmers than usual, at least in areas affected by drought, stored their maize inside the house; the quantities harvested being considered too small to justify storage on a *thangro.*

There are two main crops of paddy per year, the main crop being harvested in November/December and the second crop, which is grown only at low altitudes on irrigated land, is harvested in June/July. Paddy is stored in many different types of container but baskets and mud bins are perhaps the most important.

Methods

Assessment of storage losses. The loss assessment methodology was based on that described in Harris and Lindblad (1978). After the preliminary survey it was concluded that the study should concentrate mainly upon determining losses due to insects which appeared to be the major cause of grain loss. However, during the main study, observations of rodent activity were recorded and an attempt was made to quantify rodent losses in stored maize.

In order to estimate the total cumulative loss during the storage season the measurements of loss from samples collected at monthly intervals were related to the pattern of grain consumption according to the procedure described by Adams (1976). The quantity of each crop stored was estimated at the beginning of the storage season and at each monthly visit the amounts of grain removed since the previous visit were recorded together with details of grain use. The field investigators were instructed to collect a sample of approximately 1 kg of grain or ten maize cobs from each selected store but, because of traditional beliefs in the presence of a household god, they were not always permitted to enter rooms in which grain was stored. The field investigators were able to establish a good understanding with many of the sample householders, to the extent that they were no longer regarded as strangers and were allowed access to the grain stores, but in a few cases they had to rely upon a member of the household to draw the sample. In such cases, the same member of the household was asked, whenever possible, to collect the sample each month but there was no guarantee that the sample would be taken from the quantity of grain that was currently being withdrawn for consumption. This problem did not so much affect the study on maize because many farmers stored their maize cobs on platforms *(thangros)* outside the house or hung the cobs in bunches under the eaves.

Wheat and, sometimes, paddy were stored in several small containers rather than a single large store and there was no regular pattern of removal of grains. Any particular container may not have been emptied before grain was taken 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 per store.

Field investigators made a visual assessment of the quantities of grain in store and of grain removed at each visit, or used local standard volumetric measures. When it was not possible to enter a house farmers were asked how much they had stored at the beginning of the season, how much had been removed and how much remained. The reported figures were compared with records made at previous visits and any discrepancies questioned. Overall, this procedure worked well and no inexplicable differences between quantities stored and quantities removed were noted.

The survey of wheat loss was restricted to 49 sample households of which 41 provided complete, satisfactory, results. During this early phase of the project it was possible to return all grain samples to Pakhribas for analysis. Losses due to insect infestation were assessed by following the changes in the dry weight of a standard volume of grain. This preliminary investigation of losses clearly demonstrated that such an intensive sampling programme and method of analysis would not be possible in the main study of maize because of the difficulties of transporting 200 samples per month to Pakhribas and the length of time needed to complete the analysis. It was therefore more appropriate to adopt a simpler technique of sample analysis which could be undertaken by the investigators in the field. Losses in maize were calculated from an assessment of the percentage damage in a sample of ten cobs. The percentage damage was converted to a weight loss by dividing by 6.2, a conversion factor determined by laboratory analysis of grain samples drawn from 50 households. Samples of grain from these 50 households (10 per *panchayat*) were returned to Pakhribas every month and losses assessed by the standard volume weight method. These samples were used as a cross check on the field estimates and it was found that the results obtained by the two methods agreed closely, although estimates obtained by the standard volume weight method were slightly higher. Seventy six households were eventually selected for the study of losses in paddy but satisfactory results were obtained from only 53. All paddy samples were returned to Pakhribas for analysis and insect losses were assessed by the standard volume weight method.

Assessment of insect losses. The standard volume weight method requires that a baseline graph should be prepared to predict the dry weight of a standard volume of grain at a range of moisture contents since this dry weight is known to vary with changes in moisture content (Harris and Lindblad 1978). Ideally a baseline graph should be prepared for each store under study but in this project such a refinement was quite impracticable because of the limited laboratory facilities, the time constraints and difficulty of transporting the large initial samples to Pakhribas. Two baseline graphs were prepared for the study of wheat losses; one for each of the two distinct groups of wheat varieties, ie "traditional" and "improved", using aggregate data from the first samples collected. A single baseline graph was prepared for maize since no significant difference was found between the stores and the volume weight/moisture content relationships of maize from the five *panchayats*. Difficulties were experienced with paddy. It was thought that a single baseline graph per *panchayat* would suffice since the varieties grown were traditional to each individual *panchayat*. However the variation in the standard volume weight (bulk density) between varieties even within a *panchayat* were so great that it was impossible to prepare a graph using aggregate data. The degree of variation in the standard volume weights for paddy was far greater than for wheat or maize. This might be explained by one or more of the following factors:

a. the farmers traditionally select and store seed from their own production and this practice may have produced a range of distinct genotypes, with a corresponding wide range of bulk densities;

b. the time of harvesting in relation to maturity has a significant effect on the shape and size of the grains and consequently on the bulk density; (the period of harvesting extended over a period of 4-5 weeks and some farmers harvested early, before the rice grains were completely filled. Harvesting was interrupted by rain and during this time further growth might have occurred, in that part of the crop remaining in the field, with the result that any distinct variety from one field might have shown two widely differing bulk densities.)

c. the crops were grown on sloping fields or on terraces on steep slopes and it is likely that a certain amount of leaching of nutrients occurred, from higher to lower parts of the field, which might result in grains with differing bulk densities;

d. paddy was stored in a number of small vessels rather than in one large store and each vessel may have contained grain from different parts of the "field", each sample exhibiting a different bulk density.

Since the preparation of individual baseline graphs was not practicable the standard volume dry weights of the initial paddy samples from each store were used as baselines from which to measure losses. The procedure was adequate although there were some inconsistencies in the results usually in situations where paddy was stored in several vessels. The monthly samples may not have been strictly comparable with the first samples because of the bulk density variations, within a variety, mentioned above.

Losses due to rodents. It was not possible to obtain a measurement of rodent losses in wheat and paddy but an estimation of rodent losses in maize was attempted by examining each monthly sample of ten cobs for evidence of rodent damage. The average percentage damage which could be attributed to rodents was taken as the weight loss in the sample. It was assumed that the percentage damage equalled the weight loss since rodent-gnawed grains remaining on the cob would be discarded after shelling. This method assumes that all grains are of equal weight and is clearly subject to error. A short investigation to determine the likely error demonstrated that the percentage damage per sample was, on average, underestimated by 2.5% and the overall effect of this was to raise the total recorded loss due to rodents by 0.4%.

Mould damage. An estimate of loss due to mould was made by measuring the amount of damaged grain rejected by the household as unfit for consumption. The small amount of mould damage in wheat and paddy was regarded as insignificant by households and therefore no loss was recorded. Mould damage in stored maize cobs was more severe and the weight loss was calculated from the percentage of damaged grains (using the same method used for rodent losses) and converting this to a whole grain equivalent.

Results

Wheat. The study of the wheat crop was a preliminary exercise to gain experience and was not expected to provide good estimates of loss. Nevertheless, adequate results were achieved for 41 of the 49 sample households and an average weight loss of 2.4 ± 1.9% due to insects (mainly *Sitophilus* spp) was recorded for a storage period of three months. Traditional varieties of wheat stored as unthreshed ears appeared to suffer greater insect damage than the improved varieties which were always stored as threshed grain. However, the difference between the levels of loss (3.0% in traditional and 2.0% in improved varieties) was not statistically significant.

Maize. Adequate results were obtained from 177 of the 200 sample stores. The data from the remaining 23 stores were incomplete because the farmers either abandoned their land or refused to allow the field investigators to collect samples from the stores. The average total weight loss during an average storage period of 6.1 months was 5.7 ± 3.2%. Of this 0.6% was due to insects, 3.7% due to rodents and 1.4% due to mould.

The study confirmed earlier observations by Cunningham and Howarth (1978) that insect losses in stored maize were likely to be more severe at lower altitudes, where the crop is harvested during the monsoon (July-August) when conditions are conducive to rapid insect development. The harvested cobs are stored temporarily inside the house, with further exposure to insect infestation from other stored crops, before being transferred to *thangros* or hung under the eaves. 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. Furthermore, the cobs are rarely taken into the house but stored on *thangros* or under the eaves immediately after harvest. Losses were expected to increase with the length of the storage period and an analysis of insect losses, which included the elements of altitude and time, is summarised in Table 1. The level of loss, particularly at the lower altitudes, is perhaps lower than might be expected in normal years because crop yields were reduced due to drought. Maize at the lower altitudes was quickly consumed and 68% of the sample households in this group had used up their maize after four months. At these altitudes (600m - 1200m) the loss due to insects was higher in the *panchayats* unaffected by drought than in those affected by drought: the average was 1.2%, after about 7 months storage, as compared to 0.7% in Table 1. No significant differences were found in the levels of loss due to rodents at different altitudes but the average loss in maize stored inside the house was significantly higher (13.3%) than in maize stored outside on the thangro (3.9%).

Table 1 Percentage weight losses in stored maize due to insects

Altitude	Storage period (months)		
	1 – 4	5 – 8	9 +
600 – 1200m	0.3	0.7	1.1
No. of farmers	53	14	10
1200 – 1800m	0.4	1.0	1.4
No. of farmers	18	17	24
Above 1800m		0.1	0.4
No. of farmers	-	14	27

It is possible that the figure for storage loss due to mould damage (1.4%) includes an element of pre-harvest damage. Work at Pakhribas demonstrated that at harvest time, in the area around the Agricultural Centre, 10-13% of maize cobs were seriously affected by pre-harvest fungal damage. Higher storage losses were recorded at the lower altitudes and although the differences were not significant, more mould damage was to be expected here because of a greater incidence of the storage of high moisture content maize cobs in piles on the upper floors of the houses.

Paddy. The study of losses in paddy was restricted to four *panchayats.* The results from 53 of the 76 households sampled initially were included in the final analysis. The average weight loss due to insects (mainly *Sitotroga cerealella* and *Sitophilus* spp) was 3.3 ± 2.2% over an average storage period of 7½ months, with no statistically significant differences between losses at different altitudes. It was not possible to estimate losses caused by rodents although obervations indicated that rodents were damaging and spoiling considerable quantities of grain. In many samples a high proportion of rodent damaged grain, in the form of empty husks and broken rice grains, was recorded, There were no recorded losses due to mould damage.

Discussion

The level of storage losses recorded in this study (approximately 5% for maize) are considerably lower than the 10-30% previously reported (Rana and Ganesh 1977). The extremely dry year in which the study was undertaken resulted in reduced crop yields and consequently a shorter storage period, especially for maize at the lower altitudes. Under these conditions it is reasonable to expect reduced levels of insect loss during storage. Insect damage to stored maize frequently begins immediately after harvest and would continue until the colder, winter months. Insect activity would resume in the following April and would increase rapidly during the monsoon. During the period of the study many farmers, especially those growing maize at lower altitudes, consumed their maize within four months of harvest and this would limit the extent of loss due to insects. Under normal conditions the period of storage would be much longer and the risk of damage, by insects and perhaps rodents, would be greater; possibly resulting in weight losses at least twice as great as those recorded in this study. Even so, the evidence suggests that the loss due to insects (about 1.2% after 7 months storage) would not be very great.

Households were invariably infested by rodents which may be responsible for significant weight losses of stored grain. However, it is debatable whether the loss due to rodents would be greater in normal crop years since the proportion of the total harvested crop stored in the house would be less. Maize would be transferred to the *thangro* where it appears to be less susceptible to rodent attack.

Mould damage during storage is likely to occur more at the lower altitudes when the crop is harvested during the rains and stored at a high moisture content inside the house. During this study the cobs were often kept, throughout the season, inside the house instead of being transferred to the *thangro* soon after the rains. When cobs are stored on the *thangro* loss due to mould damage is less severe.

The studies of wheat and paddy provided valuable experience in developing the methodology for the assessment of losses due to insects. The studies can only be regarded as supplementary to the main study and there must be some doubt about the reliability of the results because of the small sample size and restricted survey areas. However the results perhaps give a better indication of the order of magnitude of loss than has hitherto been available. Whilst it may not be possible to justify a major loss reduction programme on the basis of the results of this study the low level of loss is not a reason for dismissing storage extension work as unimportant. The potential exists for serious losses due to rodents and insects in the traditional farming system. Any introduced change that might affect storage practices, such as the cultivation of new varieties (which are commonly more susceptible to insect attack) or an increase in the amount of grain to be retained on the farm, could lead to a significant increase in losses. Efforts are being made to increase production in this part of Nepal and if these lead to widespread introduction of new, improved grain varieties insect infestation during storage is likely to become a serious problem (Boxall *et al*, 1978).

The hills of Nepal are regarded as food deficit areas and a reduction of even the small storage loss recorded in this project may be regarded as important. There is a need to improve store management and basic hygiene to reduce problems of infestation. Farmers might be encouraged to empty and clean their stores between storage seasons to prevent the carry over of insect infestation from one crop to another in grain residues. Rodents are a serious problem particularly where maize cobs are strewn over the floor of the house but damage is apparently less where the cobs are neatly stacked. This point perhaps needs further verification but farmers should be encouraged to stack their maize cobs, if only as a step towards improving the standard of hygiene and store management.

Some traditional containers are inadequate for storage; for example, the small vessels commonly used for storage of wheat and paddy cause problems in stock management, whereas others (such as large baskets and mud bins) are basically sound and could be improved easily, to exclude rodents, by providing them with lids.

Maize cobs stored on *thangros* are vulnerable to rodent attack but this is only severe when the structure is built close to the house, when rodent access from the upper floors of the house is easy. A reduction of rodent losses might be achieved simply by relocating the *thangros* at least 2m from the house.

Insecticides and rodenticides are rarely used to protect stored grain in the Eastern Hills although their use is increasing. Widespread introduction of pesticides cannot be justified by the results of this study, which shows the need for simple good housekeeping and hygiene to restrict rodent harbourages and access to grain and to avoid the carryover of insect infestation from one season to the next. However, it is quite likely that the availability of pesticides to rural farmers will increase. Thus there will be need to review the situation, with regard to the effects of possible production increases, including the possible increased availability of pesticides, and to establish whether or not there may be need, at a later stage, for suitable pesticide treatments to protect farm-stored grain.

Acknowledgements

We are indebted to the Gurkha Reintegration Scheme, Pakhribas Agricultural Centre (PAC) and the Kosi Hill Area Rural Development Programme (KHARDEP) for their assistance and cooperation in undertaking this study. We especially wish to thank Lt Col J A Lys, Manager, PAC and Mr R N Jenkin, Senior Technical Adviser, KHARDEP, for their support. Thanks are also due to the six field investigators for completing the survey work under difficult conditions. A full report on the work has been published by the Tropical Development & Research Institute (formerly TPI) as Report No. G157 (by the same authors).

References

ADAMS, J M 1976. A Guide to the Objective and Reliable Estimation of Food Losses in Small Scale Farmer Storage. *Tropical Stored Products Information;* **32,** 5–12.

ADAMS, J M and HARMAN, G W. 1977. The evaluation of losses in maize stored on a selection of small farms in Zambia with particular reference to the development of methodology. TDRI (TPI) Report G109.

BOXALL, R A, GREELEY, M and TYAGI, D S, with LIPTON, M and NEELAKANTA, J. 1978. The prevention of farm level food grain storage losses in India; A social cost benefit analysis. IDS Rsearch Report, Institute of Development Studies, University of Sussex, Brighton, England. 15BN No. 0–903354–65–9.

CONLIN, S and FALK, A. 1979. A study of the Socio–economy of the Kosi Hill Area. Guidelines for planning an integrated rural development programme. 2 Vols. KHARDEP Report No. 3. Kosi Hill Area Rural Development Programme, Kathmandu, Nepal.

CUNNINGHAM, A and HOWARTH, S. 1978. Observations on current grain storage practices and problems in the PAC Target Areas and Recommendations made with regard to LAC and PAC. Duplicated Report. Pakhribas Agricultural Centre, Nepal.

HARRIS, K L and LINDBLAD, C J (Compilers. Post harvest grain loss assessment methods, xii + 193pp. Published by the American Association of Cereal Chemists, in co-operation with the League for International Food Education, the Tropical Products Institute, the Food and Agriculture Organisation of the United Nations and the Group for Assistance on Systems relating to Grain After-harvest (1978). ISBN No. 0–913250–14–7.

RANA, P N and GANEŞH, K K C. 1977. Report on the studies of different types of storage structures in Nepal. *Nepal Journal of Agriculture;* **12,** 203–213.