SOME ESTIMATES OF FARM–LEVEL STORAGE LOSSES OF RICE IN BANGLADESH

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Abstract

This paper relates to farm-level storage of Aman (winter) season paddy (unhusked rice) and rice in 1978-79. The estimates are based on work from the first year of the Institute of Development Studies post-harvest research project in Comilla district of Bangladesh. After a description of the causes of loss arising during farm-level storage, the problems of loss measurement and the methods adopted are explained. Estimates of quantitative losses of paddy and parboiled rice, in a variety of different storage structures, are given with a 'best estimate' of average physical loss (2.04 per cent). A factor (1.25) has been calculated to convert the physical loss of paddy to a loss of food, so as to obtain an overall estimate of average food loss (2.43 per cent). The results are briefly discussed with regard to the relative performance of raw and parboiled grain and to possible implications for policies concerned with reducing post-harvest loss.

Résumé

Ce document concerne l'emmagasinage au niveau des fermes du paddy (riz non-décortiqué) et du riz d'hiver Aman pour l'anneé 1978-79. Les chiffres ont été tirés des travaux réalisés pendant la première année du projet de recherche post-récolte du Institute of Development Studies dans la zone de Comilla du Bangladesh. La description des causes des pertes survenant pendant la période d'emmagasinage dans les fermes est suivie d'une explication concernant les problèmes de mesure des pertes et l'adoption des méthodes. On évalue les pertes quantitatives de paddy et de riz à demi-cuit dans toute une variété de structures d'emmagasinage et l'on donne 'la meilleure évaluation possible' de la perte physique moyenne (2,04%). Le calcul d'un facteur (1,25) permet de transformer la perte physique de paddy en perte d'aliment, afin d'obtenir une évaluation globale de la perte d'aliment moyenne (2,43%). Les résultats sont brièvement discutés au regard de la performance relative de la céréale crue et à demi-cuite et des incidences éventuelles sur les mesures permettant de réduire les pertes post-récolte.

Introduction

The post-harvest foodgrain system for rice in Bangladesh involves a series of well defined stages from harvesting, through threshing, parboiling, drying, storing and milling. Food losses occur at each of these stages but they are difficult to measure with precision because of the enormous variability that exists in the techniques used, the timing of operations and their sequence.

However, useful estimates of food loss in cereals are possible and are considered essential to the development of policies aimed at improving the efficiency of rice storage and processing. One of the objectives of the Institute of Development Studies project is to establish reliable estimates of the amount of food lost at each stage of the village level post-harvest system. Field investigations are being conducted over a two and a half year period in eight villages in two districts of Bangladesh. This paper summarises the results of the research work undertaken in the Aman (winter) season, 1978-79, to estimate the size and causes of farm level storage losses in four villages in Comilla district.

Rice is stored after drying as raw paddy (unhusked rice) and after parboiling and milling as parboiled, husked rice. The different pre-storage practices employed in the processing of paddy have an important bearing on the subsequent keeping quality. For example, the climatic conditions prevailing during harvesting will affect the moisture content of the grain which is an important determinant of the level of infestation by fungi and insect pests. Drying techniques also have a profound effect on storage and milling of grain. For example, inadequate drying may lead to severe insect infestation and mould growth in store.

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In terms of time, storage is the most significant stage of the post-harvest system. Losses during storage may be described as quantitative and qualitative. Quantitative loss is defined here as a physical weight loss and is regarded as the most significant type of storage loss as it can be readily measured. In this project such loss was due to the activities of insect pests, rodents, and occasionally birds. Qualitative losses are more difficult to measure and evaluate, particularly when considering taste or texture with regard to consumer preferences. Nutritional losses and chemical changes occurring during storage were not considered in this project because they are difficult to measure and interpret. Clearly there is need for further research on quality deterioration in cereals and cereal products and the effect on human health of consumption of deteriorated and mould infected grains.

Assessment of losses in storage

The methods employed for assessing losses in storage were adapted from Harris and Lindblad (1978).

A total of 111 paddy or rice stores were sampled after the 1978-79 Aman season harvest. These stores were selected from sample farmers in the four project villages. The uneven distribution by commodity and by store type (see Table 1) shows the relative importance of the different storage patterns. These patterns were identified in detail during a preliminary survey of the four villages.

The sample farmers were visited immediately after harvest to weigh their grain into the selected store and to collect a sample of grain to establish its condition at the time of storing. This sample provided the baseline information for an assessment of losses throughout the subsequent storage period in the selected store. Details of the construction, capacity, age, and condition of the store were recorded with a brief history of the grain from the time of sowing. Samples of approximately 1 kg of grain were collected regularly from each store at intervals of four to five weeks. The estimates of paddy/rice loss are based on physical dry weight loss; ie weight loss measured by comparing the weight of grain stored and the total weight of grain eventually removed after standardising the grain moisture content at zero. This figure for total weight loss consists of two separate elements; i) reduction in weight due to insect and mould activity and ii) complete physical removal of grain, mostly by rodents. Methods of estimating insect losses are well developed but there is no reliable method for estimating rodent losses. The procedure adopted in this project was to estimate the total loss due to insects, to subtract this figure from the total physical weight loss, and to ascribe the remainder to rodents. Field observations were made to determine the species of rodents present and to confirm whether or not this loss was in fact attributable to rodents. The major species recorded were *Rattus rattus, Mus musculus* and *Rattus norvegicus*. It was observed that some of the loss was due to wild birds and domestic chickens.

Farmer cooperation was good and it was usually possible to arrange for sampling to coincide with the time that grain was to be removed from store by the farmer. Samples were taken at the time of removal by picking handfuls of the grain as it was taken out, thoroughly mixing these and taking approximately 1kg for analysis. On some occasions sampling did not coincide with the farmer's removal of grain and in this situation more representative sampling was achieved by withdrawing a sample from different parts of the store using a compartmental grain probe. The quantity of grain removed since the previous visit, its use, evidence of rodent damage and insect species present were recorded at each visit. The major insect species were *Sitotroga cerealella (Oliv.), Sitophilus oryzae (L.),* and *Rhyzopertha dominica (F.).*

Insect losses were determined by two of the commonly used methods; i) by determining the standard volume weight of grain samples and ii) by counting and weighing damaged and undamaged grains. An accurate estimate of the percentage weight loss was obtained by comparing the dry weight of a standard volume of sieved grain from a sample with the dry weight of a standard volume of the baseline sample collected at the time the grain store was filled. The percentage weight loss in a sample was multiplied by the proportion of the total quantity of grain that was removed at the time of sampling. By summing up the resulting figures for all removals, a total storage loss due to insects was obtained. Where sampling did not coincide with grain removals the loss figure from the sample was applied to the quantities of grain removed two weeks either side of the sampling date.

In the second method of estimating weight loss a sample of 1000 grains was divided into undamaged and damaged fractions, and the grains in each fraction were counted and weighed. The percentage loss was calculated by a formula that measures the weight loss in the sample expressed as a percentage of the weight of 1000 sound grains.

A disadvantage of this second method is that hidden infestation results in an under-estimation of loss. The developing insect larvae within the grains are responsible for a loss of weight but because the grains appear undamaged, with no exit hole, they are counted amongst the sound grains. At high and low levels of infestation this method is known to be unreliable. In the selected stores insect infestation was generally low and, as predicted, the standard volume weight method gave more reliable results. The laboratory analysis also included an estimation of hidden infestation and a standard milling test on each sample to supplement the methods described above. Physical loss due to moulds did not feature in the Aman season stores but the development of rancidity over the storage period was measured. Studies of storage losses in the 1979 Boro (early summer) and Aus (summer) seasons are continuing and in addition to the work described above the laboratory analysis now incorporates germination tests and chemical analysis for the presence of mycotoxins, quantified in the case of aflatoxins. The results of all these supplementary investigations will be reported later. The full sequence of laboratory operations is shown in Figure 1.

Results and discussion

Complete and reliable data were obtained for 102 of 11 sample stores. The data for nine stores had to be rejected because quantities of grain removed from the store in the absence of a field officer were not recorded. Estimates of physical weight loss for raw paddy and parboiled rice are given in Table 3. Physical weight loss is an accurate measure of food loss in husked rice because the whole grain is eaten. In paddy, the husk (and bran) have to be removed prior to consumption. Estimates of physical weight loss of paddy will only give an accurate measure of food loss if the weight loss of husk and kernel is in proportion to their parts of the total weight of the undamaged paddy. Since insects and rodents feed selectively on the kernel and there is very little loss of husk, physical weight loss understates food loss. To allow for this a conversion factor (1.25) has been calculated from milling yields (72 per cent using traditional methods) and the proportions of husk loss (10 per cent) and kernel loss (90 per cent) in total paddy weight loss due to insect and rodent attack. This tentative conversion factor gives a best estimate of food loss in paddy stores of 2.94 per cent (Table 3).

Losses of raw paddy in total and for insect and rodent loss separately were higher than for parboiled rice and in all three cases the differences were statistically significant. The obvious explanation is the difference in storage period, which was also statistically significant, but the average monthly insect loss was greater for raw paddy (0.24 per cent) than for parboiled rice (0.12 per cent). This higher average monthly loss is, however, due to two factors. Firstly, the process of parboiling kills infestation and hardens the kernel, making subsequent penetration by insects more difficult. Secondly the exponential development of insect populations under undisturbed conditions will cause higher average monthly losses the longer the storage period. The relative importance of these two factors requires

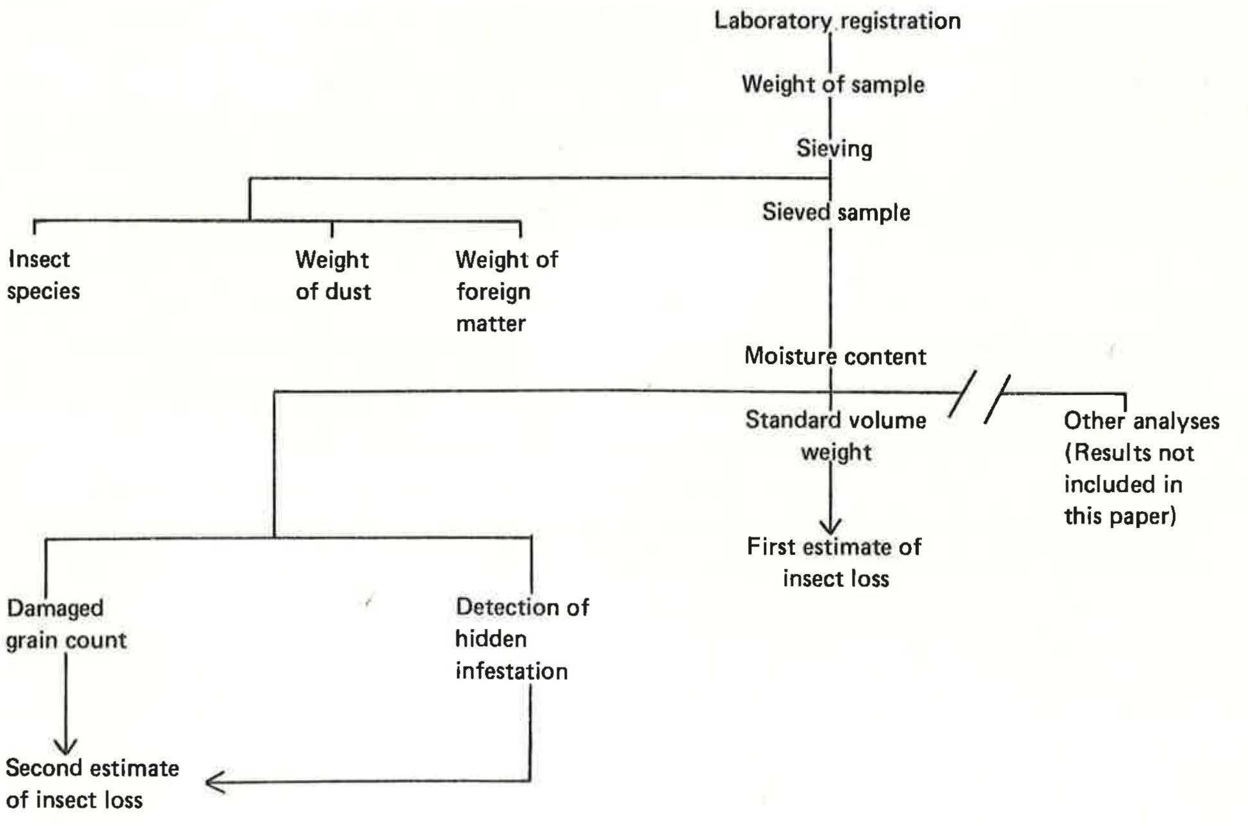

Fig 1. Sequence for laboratory processing of samples.

further examination taking into account the effects of grain removal patterns and changes in climate during the storage season.

One of the most interesting results of the statistical analysis was that rodent losses were significantly higher than insect losses for the three major store types; *doles, motkas* and bags. These together account for 57 per cent by capacity and 77 per cent by number of farm-level stores. The obvious implication of this, that rodent control is more necessary than insect control, are strengthened when account is taken of the additional benefits from reducing rodent losses in the field. The main species of rodents occur both in the farmer's field and in his farmyard and although there is some doubt concerning the accuracy of recent estimates of field loss due to rodents (11 per cent) it seems plausible that economically viable programmes are possible. Since it is also possible to make rodent control programmes very labour-intensive the real social benefits are likely to be greater than a market price evaluation would suggest.

Because of the low numbers of most store types in the sample, the only possible comparisons of losses by store type (see Table 2) were between *dole* and bag for raw paddy and *dole* and *motka* for parboiled rice. These three types of store are the major ones at the farm level. The statistical analysis produced only one significant result; grain in bags had suffered significantly greater loss than in *doles* both for rodent loss and for total loss, with no significant differences in period stored. Bags are most commonly used by small farmers who cannot afford to buy proper storage facilities and it is likely therefore that such farmers suffer most from farm-level storage losses.

Overall, the levels of losses, 2.04 per cent in weight terms, 2.43 per cent in food terms, are lower than is commonly assumed. Previous work in South India (Boxall, *et al*, 1978) demonstrated that with losses just over 4 per cent in seven months (as opposed to four months storage in Bangladesh) it was possible to identify improvements, to farm-level stores, that were economically viable with favourable social benefit-cost ratios. The lower levels of losses reported here are unlikely to support any but the cheapest forms of improvement. Loss assessment programmes should be followed by loss reduction measures only if it can be demonstrated, perhaps through a pilot programme, that provision of technical advice and necessary inputs can be of net economic value. The nature of the institutional arrangements through which such a programme can be implemented will be a critical determinant of its economic viability.

Acknowledgements

I gratefully acknowledge the work of the project field staff, Mr Latif Shahriar, Mr Abu Sayed, Mr Abdul Malek, Mr Abdul Jalil, Mr Muzaffar Ahmed, and Mr Siddiqur Rahman whose sincerity and endeavour made this paper possible. I also sincerely acknowledge the contribution of the laboratory staff, particularly Miss Syeda Shahida Begum, for analysis and processing of data at our Dacca office. I am indebted to the farmers in the project villages for their involvement and co-operation in conducting the research work. I am also grateful to the Bangladesh Council of Scientific and Industrial Research, Dacca, for providing office and laboratory facilities and to Robin Boxall of the Tropical Products Institute, ODA, UK, for his guidance on the storage work during two visits to Bangladesh.

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Table 1 **Distribution of stores by type, in the sample and throughout the four villages**

Store Type	Commodity			Total stores	Percentage distribution		
	Raw paddy	Parboiled paddy	Parboiled rice		In sample by number	In villages by number	In villages by capacity
Dole	40	2	18	60	54.0	39.8	35.6
Motka	2	1	12	15	13.5	9.3	20.0
Gola	3	1	1	5	4.5	27.6	2.9
Bag	17	1	3	21	18.9	7.9	21.4
Khari	4	-	-	4	3.7	9.3	10.2
Jabar	-	-	-	-	-	4.0	1.1
Others	3	-	3	6	5.4	2.1	8.8
Total:	69	5	37	111	100	100	100

All stores are kept inside the house

Dole: a barrel - shaped bamboo basket with narrow neck. (Figure 2).

Motka: an earthen pot

Gola: a mud-plastered bamboo bin

Bag: made from jute

Khari: a bamboo basket with rectangular base and a wide round opening. (Figure 3).

Jabar: a circular bamboo basket

Others: includes wooden boxes with a hinged lid ('chests'); see Table 3.

*Only five parboiled paddy stores were sampled. The average loss was 1.2 per cent over a period of 3.0 months. There were no raw rice stores in the project villages. Both these commodities are insignificant elements in total farm-level storage.

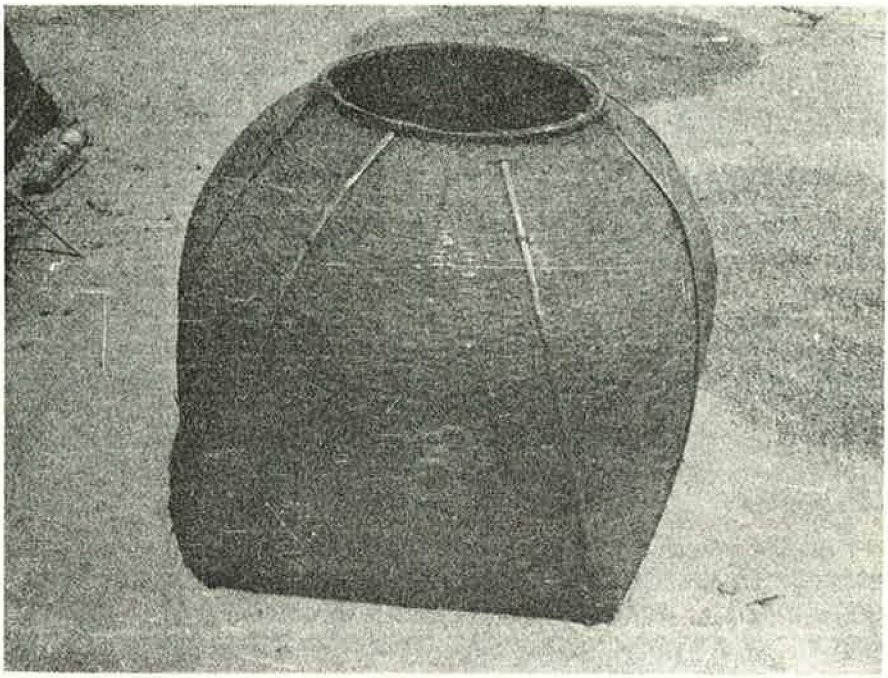

Fig 2. A store (storage container) of the *dole* type. Photo: Saleha Begum

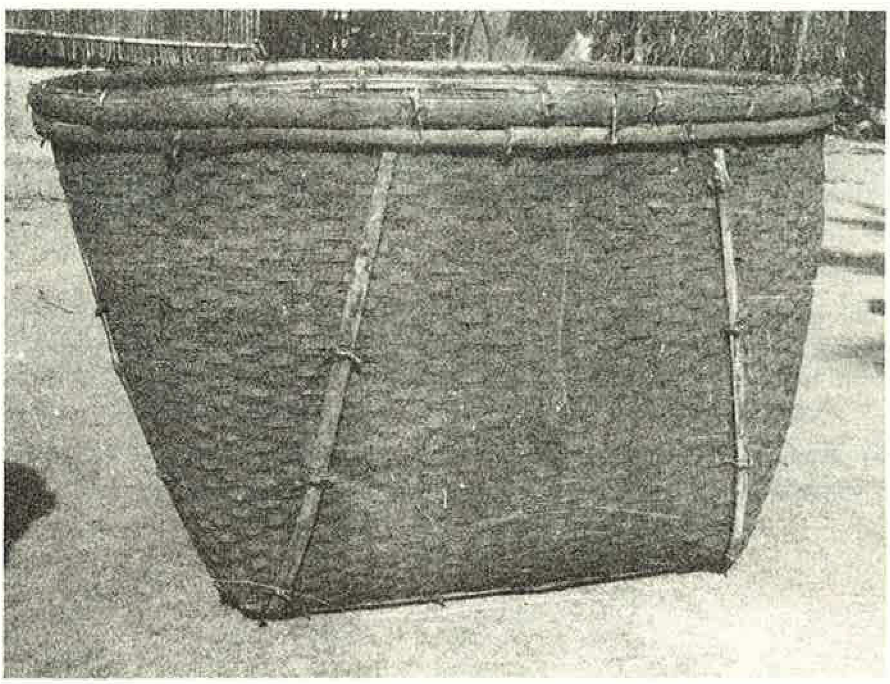

Fig 3. A store (storage container) of the *khari* type. Photo: Saleha Begum

Table 2 **Average quantities stored, storage periods and losses; by store type**

Store Type	Commodity	Stores sampled	Quantity initially stored (Kg)	Storage period (months)	Insect loss %	Rodent loss %	Total weight loss %
Dole	Raw paddy	36	60.2	4.45	0.92	1.45	2.37
"	Parboiled rice	17	109.9	2.68	0.38	1.28	1.66
Motka	Raw paddy	2	36.8	4.23	0.79	0	0.79
"	Parboiled rice	11	38.0	2.41	0.21	1.18	1.39
Bag	Raw paddy	16	30.7	4.05	1.23	2.24	3.47
"	Parboiled rice	3	35.4	1.92	0.08	0.99	1.07
Gola	Raw paddy	3	275.4	4.82	1.92	0.11	2.03
"	Parboiled rice	1	251.5	2.30	0.54	1.69	2.23
Chest	Raw paddy	1	185.9	4.20	0.87	0.64	1.51
"	Parboiled rice	2	325.7	4.20	0.43	0.85	1.28
Khari	Raw paddy	3	124.5	3.69	0.58	1.32	1.9
Drum	Raw paddy	2	59.5	4.73	2.49	0	2.49

Table 3 **Average losses for raw paddy and parboiled rice**

Commodity	Stores sampled	Average storage period (months)	Average quantity stored (kg)	Percentage loss by weight			
				Insect loss	Rodent loss	Total loss	Food loss
Raw paddy	63	4.36	67.3	1.06	1.29	2.35	2.94
Parboiled rice	34	2.71	96.9	0.32	1.16	1.48	1.48
Overall weighted average	97	3.78	77.6	0.80	1.24	2.04	2.43

Note: Food loss per cent for paddy is calculated as follows.

The initial weight of paddy is converted to its rice kernel weight when milled; ie Initial paddy weight x 72/100.

The weight loss for paddy is converted to the loss of kernel weight, which has been shown to be 90 per cent of the paddy weight loss on average. This kernel loss is then expressed as a percentage of the calculated weight of milled rice.

Resumen

El presente artículo se refiere al almacenaje a nivel de granja de arroz maduro (invernal) de Amán (sin descascarillar) y de pulido en 1978-79. Los cálculos se basan en los trabajos investigativos realizados durante el primer año del proyecto de investigación posterior a la cosecha del Instituto de Estudios de Desarrollo en el distrito de Comilla en Bangladesh. Después de una descripción de las causas originarias de las pérdidas que surgieron durante el período de almacenaje a nivel de granja, se explican los problemas de medición de pérdida, así como los métodos adoptados. Se incluyen cálculos de las pérdidas cuantitativas de arroz maduro y cocido parcialmente en una variedad de estructuras distintas de almacenaje con us "cálculo óptimo" de la pérdida física media (2,04%). Se ha calculado un factor (1,25) para convertir la pérdida física de arroz maduro en relación con una pérdida de material alimenticio, con el fin de obtener un cálculo global de la pérdida de material alimenticio media (2,43%). Los resultados se tratan de modo breve en lo que refiere al comportamiento relativo del grano crudo y cocido parcialmente, así como en lo que atañe a las posibles consecuencias en torno a las líneas do conducta relacionadas con la disminución de las pérdidas producidas después de la recolección.