THE EVALUATION OF LOSSES IN MAIZE STORED ON A SELECTION OF SMALL FARMS IN ZAMBIA, WITH PARTICULAR REFERENCE TO METHODOLOGY

by

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Abstract

A report on research into quantitative and qualitative losses incurred during maize storage on selected small farms is summarised. Various methods of analysing samples for loss were tested. The best estimate of loss within a sample was obtained by comparing the weight of a standard volume of grain from the sample with that of a reference sample obtained at the time of storage. Estimates of loss over a storage season were obtained by integrating losses within samples with the pattern of consumption over the storage period. Monetary values were placed on these losses. Methods for evaluating changes in storage practices are described and the costs and benefits of a simple improved storage technique are calculated.

Résumé

Résumé d'un rapport sur la recherche des pertes quantitatives et qualitatives qui se produisent au cours du stockage du mais dans de petites fermes choisies. Examen de différentes méthodes d'analyse des pertes dans les échantillons. On a obtenu la meilleure estimation des pertes à l'intérieur d'un échantillon en comparant le poids d'un volume standard de grains de l'échantillon à celui d'un échantillon de référence obtenu au moment du stockage. On a estimé les pertes tout au long d'une saison de stockage en intégrant les partes à l'intérieur des échantillons avec le type de consommation durant la période de stockage. On les a exprimées en valeurs monétaires. On a décrit des méthodes d'évaluation des variations dans les pratiques de stockage et on a calculé les prix de revient et les bénéfices relatifs à une technique simple et améliorée de stockage.

Resumen

Se resume un informe sobre la investigación de las pérdidas cuantitativas y cualitativas ocurridas durante el almacenamiento del maiz en pequeñas granjas seleccionadas. Se probaron varios métodos de análisis de muestras para conocer las pérdidas. La mejor estimación de pérdidas en una muestra se obtuvó comparando el peso de un volumen estandar de grano de dicha muestra con el de una muestra de referencia obtenida durante el almacenamiento. La estimación de las pérdidas durante una temporada de almacenamiento se obtuvó integrando las pérdidas en las muestras dentro del modelo de consumo y durante el periodo de almacenamiento. Se calcularon los valores monetarios de estas pérdidas. Se describen los métodos para valorar los cambios en las prácticas de almacenamiento, y se calculan los costos y beneficios de una técnica de almacenamiento sencilla mejorada.

Introduction

This article summarises the work of a 13 month research project conducted in Zambia by the author and G W Harman, an economist from the Tropical Products Institute. The project was funded by the Economic and Social Committee for Overseas Research of the United Kingdom Ministry of Overseas Development. A full report is available from the Tropical Products Institute as Report G109. It contains considerable information of use to those contemplating a detailed study of storage losses at the rural level. The Project began at the time of the maize harvest in May 1973 and continued into the next harvest in May 1974.

The main intentions of this Project were to investigate and evaluate various methods that could be used to assess the physical storage losses in grain incurred by small scale farmers and to apply the losses determined by appropriate methodologies to an evaluation of the costs and benefits of a simple improved storage technique which was being recommended by the Food Conservation and Storage Unit of the Department of Agriculture. It was not intended that the loss estimates produced by the project should be interpreted as being representative of Zambia as a whole nor of any particular region.

In order to evaluate the cost/benefit of an improved storage technique data were originally sought both from farmers using traditional storage methods and from those using the improved methods. However, there were insufficient farmers in the survey areas who had adopted all the recommended improvements, so the analysis was based on a group of simulation stores built by the project and compared with the traditional farm stores in the survey areas.

Research Programme

The project was based at The Central Research Station of the Department of Agriculture, Mt Makulu, near Lusaka and preliminary visits were made to select possible project areas which would be easily accessible from this location. One of the two areas selected, Chalimbana, was approximately 45 km east of Lusaka and contained a high proportion of farmers storing shelled maize in mud lined stores (Figure 1). The other area, Chivuna, was approximately 150 km south of Lusaka and the majority of farmers there stored cob maize in traditional thatched timber stores or in thatched mud brick stores (Figure 2). Both these types of cob store had apertures in the walls which allowed free ventilation of the cobs.

A case study approach was used for which close co-operation was essential, so farmers were not chosen randomly within these areas. Since they were not intended to be statistically representative the choice of 8 farmers was made with the help of the local extension staff. A detailed questionnaire schedule was completed, through an interpreter, for the selected farmers and their immediate neighbours at both the start and end of the project. A shorter questionnaire schedule was also completed for another 68 farmers in the vicinity of Chivuna and 40 farmers around Chalimbana. This was used to obtain basic data on factors related to storage practices. The results showed that the farmers selected for the case study could be considered typical of the areas studied.

The farmers included in the case study were visited as soon as possible after their maize was harvested, the quantity placed into store was determined both by questioning and by measuring the capacity of the stores and a reference sample of grain was removed from each store. Further samples of 10 cobs or 1 kg of grain were removed from each store every two weeks until the store was empty. Samples were taken as if for consumption and the farmer or his wife was asked to reject any maize that would not have been used for food. This maize was recorded as a food loss but any alternative use was noted. In addition a record was kept of the quantity, by volume, removed from each store since the previous visit and the uses to which it had been put.

Parallel to this field study a group of traditional and improved stores was built at the project's base, the additional time taken to effect the improvements being recorded. The stores were filled with maize purchased from farmers in Chivuna and grain was removed regularly throughout the storage period as if for consumption. All the maize was weighed into and out of storage. Samples were also taken from these stores in the same way as from the farmers' stores.

Every sample was analysed for moisture content, number and species of insects, dust weight, weight of a standard volume and percentage damaged grains. Losses in quality were estimated using a grading system based on the standards set up by the National Agricultural Marketing Board, with account also being taken of a farmer's or his wife's rejection of maize unfit for consumption. The farmers were observed to accept lower quality maize for food as their stocks diminished.

Losses in quantity in the simulation stores were obtained by weighing all the maize removed and deducting this from the weight of maize entering the store. For the purpose of comparison all losses were adjusted to dry weight of shelled grain. These losses were then compared with those estimated from the samples taken from the same stores. Various techniques were used to obtain estimates of weight loss within samples. Each estimate was then applied to the quantity of grain removed since the previous sampling occasion. The resultant fortnightly loss figures were totalled to give an estimate for the whole storage period. The method that gave the best estimate when compared with the measured loss in the simulation stores was then applied to the farmers' samples.

Losses incurred in storage

Measured weight losses in the simulation stores (Table 1) show the effectiveness of the recommended improvements. In fact the maize purchased by the project was likely to store badly since it was that which the farmers had rejected for storage. Most of the farmers selected uninfested tight husked cobs to place in store, selling off where possible the larger cobs which were more susceptible to insect attack. Those not suitable for storage which were not sold tended to remain on the drying platforms for immediate consumption. In the analysis of samples, dust weight, number of insects, weight of a standard number of grains and number of insects bred out were shown to give unreliable estimates of loss.

Fig 1. Mud-lined shelled grain store from the Chalimbana area.

Fig 2. Thatched mud-brick cob-store from the Chivuna area.

Table 1 **Dry weight losses in simulation stores**

Store type	Treatment	% dry weight loss
Traditional	Without husks	8.9 *
	With husks	13.0
Improved mudded	Shelled	2.6
	Shelled + insecticide	1.1
	Shelled + insecticide, left unopened for 4 months	0.0

* this maize had already suffered at least 5% loss prior to storage.

The following formula, based on percentage damaged grains was also used:

$$\% \text{ weight loss} = \frac{(UNd) - (DNu)}{U(Nu + Nd)} \quad 100$$

in which U is the weight of undamaged grains

D is the weight of damaged grains

Nu is the number of undamaged grains

Nd is the number of damaged grains

This was found to give reasonable estimates at intermediate damage levels but was inaccurate at low levels, occasionally leading to negative estimates.

The percentage damaged grains was related to the percentage weight loss in the ratio 8:1 but this relationship failed to be reliable at high damage levels. It was also complicated in the case of cobs stored with husks on, in which localisation of the damage led to a 5:1 damage to loss ratio; however, multiple regression analysis including time in store as a variable showed that an additional allowance of 0.15% loss per week in store was necessary to obtain an accurate estimate of weight loss for cobs with husks.

Of all the factors studied the dry weight of a standard volume of a sieved grain sample compared with the same volume of the reference sample taken prior to storage gave the best estimate of loss. A correction had to be made for changes in grain volume due to variations in moisture content but this simply involved setting up five sub-samples from the reference sample with different moisture contents, measuring the dry weight of the standard volume for each and plotting the dry weight against the moisture content, and calculating a regression equation. A reference dry weight could then be obtained for any observed sample moisture content for comparison. Dry weight loss was then estimated as follows:

$$\% \text{ dry weight loss} = \frac{a - b}{a} \times 100$$

where a is the predicted dry weight of the reference sample at the same moisture content as

b which is the dry weight of the standard volume of the field sample.

This method was used to estimate the weight losses in the farmers' stores since it was the most accurate method and simple to use.

Weight loss of maize in the farmers' stores increased as the season progressed and at the end of the storage period was 8-10%. However, when the reduction in stocks throughout the season was taken into account, losses ranged from 2-6% of the total put into store. The low magnitude of some of these losses demonstrates the benefit of cob selection by the farmers.

Farmers were aware that their maize suffered damage and it was decided that the most realistic assumption to make in converting their weight losses into economic terms was to place a value on the maize lost reflecting the use to which it would have been put. Each case study (ie individual farmers) was evaluated in turn and the losses of farmers with cob maize in store ranged from K0.36 (£1 = K1.40 approximately) for a farmer with one store whose maize was finished before the onset of any appreciable loss, to K12.33

for a farmer with four stores who had sufficient maize until the next harvest, but who experienced much heavier damage to his stored crop. Weight losses were also evaluated economically using the average price at which farmers purchased maize. However, there was no significant differential in the price of maize bought for different purposes and the results obtained from using this method of evaluation were very similar to those already outlined.

Quality losses were evaluated by attaching a price to the store on the basis of the amount to be paid for each grade by the National Marketing Board. The values obtained by this means were summed to give the value of total withdrawals. This total was then deducted from the value obtained by assuming all withdrawals could have been of the top grade. The values of loss obtained ranged from K0.15 to K15.51 and when expressed as a percentage of the maximum possible value of the maize concerned quality losses ranged from 0.7% to 24.2%.

Most farmers used insecticide on their stored maize. However, none of those included in the case studies used the recommended insecticide and the treatment applied was generally ineffective. The cost of any insecticide used by the farmer was included in assessing the total loss which he incurred.

The total value of losses experienced by the farmers storing cob maize ranged from K2.16 to K36.25, with a median of K6.55. Total losses per farmer per store ranged from K2.16 to K9.06, with a median of K3.56. A single farmer storing hybrid SR52 variety maize throughout the season in the form of shelled grain suffered a total loss of K20.05. With one exception the losses in quality suffered by farmers were greater than those suffered due to loss in weight.

The total cost to Zambia of the weight loss incurred by the 8 case study farmers was calculated at K95.05.

The costs and benefits of improved storage techniques

The recommendations for improving farm stores in Zambia which were current during the project were:

1. maize should be stored, shelled
2. stores should be mudded inside and out
3. 1% malathion dust should be mixed in with the maize at the time of storage at the rate of 100g per 90kg (one bag) of grain.

The simple improved storage technique tested in the simulation stores was assessed by relating the costs involved in its adoption to the benefits received as represented by the additional value accruing to the maize stored. The major costs were the price of insecticide and value of the farmer's time in shelling his maize, mudding his store, and applying the insecticide. These were all determined and the time costed according to the statutory regulations for work of the relevant type. In assessing the relevant type of work and the extent to which a wage rate should be applied, consideration was given to the availability of alternative employment, whether the farmer was free to do it, possible preference for leisure and the fact that maize shelling is often considered a woman's or children's activity. Attention to these factors resulted in a range of costs depending on the assumptions made. The additional costs of storing by the improved technique the quantities of cobs (10 bags) and untreated grain (7 bags) put in the simulation stores were assessed to be, under the most likely assumptions, K2.80 and K0.80 respectively. Other costs, not easily valued, may be incurred owing to time spent learning and mistakes due to inexperience.

The quantitative benefit from adopting the improved method was represented by the additional quantity of maize that would have been available if, in all cases, the improved methods had been used. This amount was calculated by applying the percentage loss that occurred in maize stored in the improved way to the quantity stored in the other ways. The resulting figure was taken to represent the loss that would have occurred if the maize concerned had been stored in the improved way and was deducted from the loss which actually occurred. These amounts were then priced at the average price of farmer's maize transactions and for the above quantities the benefits were K1.73 per bag if the change was from cob storage to shelled grain storage and K0.36 per bag if untreated grain was treated with insecticide.

The qualitative benefits per farmer were assessed as before but for interstore comparison the values were reduced to the common unit of a 90kg bag which may be visualised as containing maize of various grades in the same proportion to the amount each grade formed of the total maize removed from the store. Each proportion was then valued at its respective price. The additional value of such a bag taken from maize stored in the improved manner was K0.67 when compared with maize stored as cobs with husks and K0.22 when compared with maize stored as untreated shelled grain.

The conclusion reached from comparing costs with benefits was that except when the most unfavourable assumptions were made, benefits outweighed costs. The most likely cost benefit ratio was 1 : 1.6 for a farmer currently storing cobs with husks and 1 : 2.4 for a farmer currently storing untreated shelled grain.

Apart from the nutritional benefit of using the improved methods of storage, other benefits not included in the evaluation are: greater security of knowing that the maize would remain in good condition, less cross infestation both from store to store and from store to field and a wider use of high yielding varieties that are not stored at present because of high storage losses.

The report concludes with recommendations for the planning of projects in which existing storage losses need to be evaluated along with the costs and benefits of possible storage improvements, thus ensuring the application of appropriate technology to the problem. It is also recommended that the technique be field tested with other commodities under environmental conditions, especially since each improvement project would have unique circumstances.