Grains post-harvest loss assessment in Ethiopia: Final report

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Final Report

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Abbreviations

DFID	Department for International Development (U.K.)
DPPC	Disaster Prevention and Preparedness Commission
EARO	Ethiopian Agricultural Research Organisation
EFSRA	Emergency Food Security Reserve Administration
EU	European Union
FAO	Food and Agriculture Organisation
FEWS	Famine Early Warning System
GMRP	Grain Marketing Research Project
GoE	Government of Ethiopia
MoA	Ministry of Agriculture
NGO	Non-government Organisation
NRI	Natural Resources Institute (of the University of Greenwich, U.K.)
PHC	Plant Health Clinic
SG 2000	Sasakawa Global 2000
WFP	World Food Programme

1 quintal	100 kg

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Summary

Information on post-harvest losses of food grains in Ethiopia is scarce and there is considerable debate over the importance of such losses at the farm level. A grains post-harvest loss assessment project was undertaken in collaboration with the Crop Production and Protection Technology and Regulatory Department of the Ethiopian Ministry of Agriculture (MoA) and the Ethiopian Agricultural Research Organisation (EARO). The objective of the project was to assess post-harvest losses in five main *meher* season crops: maize, sorghum, wheat, barley and beans, and to identify opportunities for loss reduction. The project was implemented in two phases. Phase I (November - December 1997) which included a desk study of locally available published and unpublished material on post-harvest losses in Ethiopia was primarily concerned with collection of background information and an initial survey of farm-level post-harvest operations at the start of the storage season. Phase II (March -April 1998), comprised further on-farm surveys and sampling for loss assessment.

A loss assessment survey was conducted in the major cereal and pulse crop producing areas of Amhara, Oromiya and Southern Regions. Cereal production was adversely affected by an unusual rainfall pattern this season. Shortage of rain during the growing period resulted in some crop failure or reduced yields, and heavy unseasonable rain at crop maturity led to problems at harvest and further crop losses. This had implications for the loss assessment exercise. In selecting sample areas, consideration had to be given to identifying those that were less severely affected and where grain was expected to be stored for several months, as well as trying to ensure reasonable coverage of the crops under study.

Group and individual farmer interviews were conducted at the start, to identify post-harvest constraints and to assess their importance in relation to the constraints in the total agricultural system. Insect infestation in storage was identified as an important problem. A common coping strategy is for farmers to sell grain early in order to avoid high losses and then to buy grain later as required. Pressure to find cash (to pay taxes and loans) as well as the fear of insect infestation during storage were the main reasons given by farmers for selling grain soon after harvest. Early sales at low prices removes an opportunity for farmers to add value to their production by selling at higher prices later in the season or for increasing household food security through retention of more grain on the farm.

Farmers' stores were sampled on two occasions, first within the first month of storage and again later in the season. Questionnaires were used to collect information on the history of the grain, details of storage methods and patterns of removal and grain use. Samples were analysed to determine loss caused by insects and mould damage using a 'count and weigh' technique, but also taking account of farmers' practices in dealing with damaged grain. The loss recorded in samples was related to the pattern of grain use to derive a cumulative figure of loss over the season.

Estimates of loss due to insects and mould were calculated for each crop and for each region. These figures were then weighted according to the contribution of each crop

to the total production of the three regions, and an overall estimate of loss of 9% (4% due to insects and 5% due to mould damage) was derived.

There was considerable variation in the levels of loss between crops. In wheat and barley they were very low (around 1%). These crops are typically grown at the higher altitudes, where insect activity is low and storage periods are short (3-4 months). Sorghum and maize suffered higher losses (4-6%). However, it was demonstrated that correct application of storage insecticides achieved a significant reduction of losses in maize (to 0.5%). Losses in beans were very variable (<1% - 15%).

Sorghum stored in underground pits was severely affected by mould (90% or more damaged grains within one month of storage). Mould damage is viewed by local farmers as more of an inconvenience than a loss; all the grain will be used for food or for brewing after washing to remove visible mould. However, high levels of mould damage have implications, not only of food loss but also of health risks to consumers.

Losses in other parts of the post-harvest system are briefly reviewed and an estimate of 11% for overall losses in grain crops is derived (table S1). Viewed in the context of an annual average grain production of 9.5 million tonnes, this is equivalent to just over 1 million tonnes. The figure corresponds closely with Loerbroks'earlier estimate. Loerbroks gave no guidance on where best to intervene to reduce losses. The figures obtained here show that on-farm storage losses may account for over half the post-harvest losses. Currently, emphasis is being given on improving food security through increased crop production using improved seed and fertiliser. The new high-yielding varieties of grains being promoted are more susceptible to pest attack after harvest and storage losses can be expected to increase further. Post-harvest improvement programmes that target peasant farmer storage can therefore be expected to achieve a significant impact in reducing losses, increasing farm incomes and improving household food security.

An end of project workshop, attended by agricultural researchers, regional officials, crop protection/ post-harvest specialists and front line extension staff, was held to review results and to discuss future action. The workshop endorsed the survey procedures and confirmed the research findings. Six areas of activity were identified for priority future action: (a) improvement of post-harvest training (agricultural schools, university undergraduate courses and MoA basic training for Development Agents); (b) promotion of basic messages of good storage practice including use of storage insecticides; (c) identification and introduction of low cost improvements to traditional storage structures (as alternatives to the relatively expensive improved structure being promoted by the NGO, Sasakawa Global 2000); (d) investigation of health risks associated with consumption of mould damaged grain from underground pits and identification of ways of reducing such damage; (e) investigation of the efficacy of indigenous materials (dusts, ashes and plant materials) as grain protectants; and (f) evaluation of small-scale mechanical threshers/shellers in areas where farmers have benefited from increased crop yields.

Some suggested areas for further DFID support to the post-harvest sector in Ethiopia are given (Annex 3).

Table S1: Post-harvest losses in Ethiopia

Total Domestic Grain Production = 9,430,000 t					
State farm production (1.6%) = 150,800 t			Peasant farmers' production (98.4%) = 9,279,120 t		
Loss at harvesting and threshing (3%)	4,524 t		Loss at harvesting and threshing (3%)	278,374 t	
Balance	146,276 t		Balance	9,000,746 t	
	Sale (90%) 132,000 t	Storage (10%) 14,276 t		Sale (28%) 2,508,000 t	Storage (72%) 6,492,746 t
Transport loss (2%)	2,640 t		Transport loss (2%)	50,160 t	
Balance	129,360 t		Balance	2,457,840 t	
Storage loss Traders (4%)	5,174 t		Storage loss (4%) Traders	98,314 t	
Storage loss Farms (4.5%)		642 t	Storage loss (9%) Farmers		584,347 t
Total available to consumers	124,186 t	13,634 t		2,359,526 t	5,908,399 t
Grand total available to consumers = 8,405,745 t			**Total Post-harvest Loss = 1,024,255 t** **of which Farm Storage Loss = 584,347t**		**10.9%** **6.2%**

Compiled from: Survey data, and secondary data from Central Statistical Authority (1997) and Grain Marketing Research Project (Dessalegn et al, 1998).

BACKGROUND

A worst-case projection of the requirement for food aid grain in Ethiopia following failure of the main rains is in the region of 2.8 million tonnes. Import capacity is estimated to be about 1.4 million tonnes and the Ethiopia Emergency Food Security Reserve Administration (EFSRA) holds stocks of around 300,000 tonnes. Loerbroks (1994) addressed the widening production-consumption gap and highlighted the need for rapid and sustained attention to increasing food production in Ethiopia. However, Loerbroks' calculations of required gross production assumed post-harvest losses of 12%, reducing to 10% in the year 2000, 9% by 2005 and 8% by 2010.

Post-harvest losses in food grains during storage result from insect and rodent feeding and fungal infection, and are now generally accepted to be around 5 percent of production in sub-Saharan Africa (Wright, 1995). Rodent feeding and fungal infection can have serious consequences for the health of the population. Losses above these levels can usually be attributed to poor storage management rather than biological agents, the introduction of a new pest complex, such as the Larger Grain Borer (*Prostephanus truncatus*), or the introduction of high yielding varieties of grain crops with poor storage characteristics.

Information on post-harvest losses in Ethiopia is scarce. However, Gutu (1993) presented data from a survey by Kidane and Habteyes (1986) which records average post-harvest losses, due to all causes, of 6.5% from three sampled areas. This scarcity of information has two effects. The first is an inability of the post-harvest sector to contribute reliable data to forecasts of food availability; and the second effect is that it is not possible to provide cost-benefit analyses for activities associated with improvements to post-harvest systems and household food security. Thus, if the figure quoted by Loerbroks is correct, it suggests an unacceptably high level of losses in Ethiopia which would require rather more attention to reduction than his targets indicate (1% every 5 years). If the 12% figure is an overestimate, then it alters the assumption on which the production scenarios are based. Average annual cereal and legume production in Ethiopia during the last five years has been in the region of 9.5 million tonnes and a difference in loss estimates of 5.5% (12-6.5%) at this level of production is equivalent to 522,500 tonnes. This is considerably more than the current stock level of the EFSRA and close to the 1997 estimate of the Disaster Prevention and Preparedness Commission (DPPC) of food requirements (572,835 tonnes) for people in need of immediate assistance (FEWS - EU 1997).

PROJECT OBJECTIVES

The objective of this project was to address the scale of post-harvest losses of food grains at the farm level in Ethiopia with a view to identifying opportunities for their reduction. The emphasis was to be away from the precise measurement of losses and to focus upon the development of knowledge of the farm level post-harvest system, its limitations and constraints and an understanding of farmers' needs as perceived by farmers themselves. Nevertheless, it was expected that the data produced could contribute to refining the calculation of required food production increases needed to halt the widening production-consumption gap.

PROJECT ORGANISATION

Food grain production in Ethiopia takes place during two periods of rainfall, the main *(meher)* rains from June to September and the *belg* rains from February to May. Over 80% of production is on peasant farms during the *meher* season and over 60% of this production is in Oromiya, Amhara and Southern Regions. The principal cereal crops are maize (30% of production), t'eff (22%), sorghum (22%), wheat (12%) and barley (10%). Broad beans, *Vicia faba,* are the most important legume crop yielding approximately 44% of total legume production (Central Statistical Authority, 1997). With the exception of t'eff, all of these crops are susceptible to post-harvest losses caused by insects. Thus, the project focused on the 1997 *meher* season crops of maize, sorghum, wheat, barley and broad beans produced on peasant farms in the three major producing regions.

The project was conducted in two phases by a three-man team comprising:
Mr R A Boxall, Post-harvest Loss Assessment Specialist, NRI, UK; Ato Teshome Lemma, Senior Post-harvest Specialist, Ministry of Agriculture (MoA) Crop Protection Laboratory, Addis Ababa; and Ato Emana Getu, Entomologist, Awassa Agricultural Research Centre, EARO. The team was supported by MoA Regional and Wereda-level crop protection and/or post-harvest specialists and front-line extension workers (Development Agents). Phase I was concerned with collection of background information on post-harvest losses, an initial survey of farm-level post-harvest operations and sampling of grain stores at the start of the storage season (November 1997 - January 1998). Phase II, comprising further on-farm surveys and sampling for loss assessment was conducted in March and April 1998.

On completion of the fieldwork, a workshop to discuss the findings of the survey and to identify priorities for future action was held at the Crop Protection Research Centre (EARO), Ambo.

INFORMATION ON POST-HARVEST LOSSES IN ETHIOPIA

A review of locally available published and unpublished information on post-harvest losses in Ethiopia was undertaken as part of Phase I (see Annex 1). The review confirmed the scarcity of information on post-harvest losses. It also showed that some of the data are of dubious quality since the methodology for assessment is poorly defined. The data represented are either average losses for several crops or crop seasons, or figures derived from experimental studies that bear little relation to the 'real world'.

The few, more reliable studies (i.e. where an acceptable methodology had been adopted and described) indicate that:

- insect damage in farm-level storage is a general problem throughout the country, particularly at the lower altitudes;
- the new, improved or high-yielding varieties of cereals and pulses tend to suffer higher losses than the traditional or 'local' varieties; and

- losses (in weight) are very variable, ranging from less than *5%* for traditional crops in well managed systems to 30% or more for improved varieties or where storage management is poor.

SELECTION OF SURVEY AREAS

The selection of survey areas was made in consultation with staff of the Regional Agricultural Bureaux, the Zonal Agricultural Development Departments and the Wereda Agricultural Development Offices. Advice was sought on the most appropriate production areas for the crops under study, keeping in mind the relatively short time and limited manpower availability. A further consideration was the effect of the unusual rainfall during 1997. The poor, short rains from January to May, and the later erratic and infrequent rains in July and August, reduced drastically both the *belg* and *meher* crop harvests. Unseasonable rains in October and November worsened the situation, causing damage to mature and maturing crops in the field, resulting in shedding of grains or mould damage and germination of grains on the ear. Crop loss surveys undertaken by MoA and EARO in November provisionally estimated that losses (due to lodging, shedding of grains and moulding/sprouting of grain on the head) ranged from 20% to 80%. Harvesting was delayed by at least 3-4 weeks and farmers in many areas faced major difficulties in harvesting, threshing and drying their crops. According to reports by the World Food Programme (WFP) and the Food and Agriculture Organization (FAQ) offices in Ethiopia, the net result was a reduction in the *meher* crop of approximately 26% over the previous year (8.8 million tonnes compared to 11.8 million tonnes). Some areas of the country were more severely affected by this unusual rainfall pattern. Compared to 1994 (the last poor production year) crop yields in North Wollo and West Gojam Zones of Amhara Region were significantly lower, and in East Goj am, North Gonder, and South Wollo they were only marginally better. North and South Wollo (important sorghum producing areas that were to be included in the survey) were identified as being in most need of food assistance (FEWS-EU 1997).

Clearly this unusual situation had serious implications for the post-harvest loss assessment exercise: in the more seriously rain-affected areas, very little grain was taken into store. Much was sold off the field to overcome the problem of drying or storage of wet grain, and yields were so low that very little grain was stored. Overall, the quantities harvested and stored were much reduced and storage periods were expected to be much shorter than usual (up to six months compared to the usual 9-11 months). In selecting sample areas, consideration was, therefore, given not only to trying to ensure reasonable coverage of the five main crops but also to identifying those areas that were less severely rain-affected and where grain was likely to be stored for several months (at least until the end of March).

Samples of bean storage were difficult to find. Many farmers in traditional bean producing areas have been reducing the area of land under beans or switching from bean production to vegetables, after experiencing serious damage by field pests and diseases, notably aphids, in the last two or three years.

The final selection of sample areas is shown in Table 1.

Table 1: Post-harvest Loss Assessment Survey - Sample Areas and Major Crops Produced.

Area	Altitude (m)	Major Crops Produced
Oromiya Region West Shewa Zone 1. *Ambo Wereda* 2. *Bako Wereda* East Shewa Zone *3. Arsi Negeli Wereda*	 2,050 - 2,300 1,750 - 1,850 1,700 - 1,875	 Maize, sorghum, wheat, barley, beans Maize, sorghum Maize, sorghum, wheat, barley, beans
Amhara Region East Gojam Zone *4. Bahir Dar Zuria* *5. Adet/Yilmana Densa Wereda* *6. Jabitihenan Wereda*	 1,820 - 1,850 2,200 - 2,500 1,700 - 1.750	 Maize Maize, wheat, barley, sorghum Maize, sorghum
South Gonder Zone *7. Laygaint Wereda*	3,000	Wheat, barley, beans
N and S Wollo Zones *8. Tehuledere Wereda*	1,800 - 1,900	Sorghum
Oromyia Zone *9. Kalu Wereda*	1,400 - 1,500	Maize, sorghum
North Shewa Zone *10. Artuma Jile, Kewot & Dawa Chefa Weredas*	1,450 - 1,520	Maize, Sorghum
SNNPR Sidama Zone *11. Shebedeno Wereda*	1,650 - 1,850	Maize
Kembata Alaba and Tembaro Zone *12. Alaba Wereda*	1,700	Maize, sorghum

PRELIMINARY SURVEY

Group and individual farmer interviews were conducted at 16 locations in the three regions with the objective of identifying post-harvest constraints and assessing their importance in relation to the constraints in the total agricultural system. Some problems or constraints were peculiar to a particular area but many were common throughout the regions, although farmers may have assigned them different priorities. The overall ranking of agricultural constraints is given in Table 2.

The majority of farmers identified the erratic weather pattern of recent years as a major constraint. Many tended to rank post-harvest (storage) problems below pre-harvest problems such as the high price of fertiliser, the impact of field pests and the shortage of land. In some areas, shortage of oxen (for ploughing and threshing) was considered more important than storage problems.

Table 2: Agricultural constraints ranked in order of importance as perceived by farmers

Rank	Agricultural constraint
1.	Erratic weather conditions
2.	Cost and availability of fertilisers
3.	Shortage of land (increasing population pressure)
4.	Field pests and diseases (including army worm, stalk borer, African boll worm, termites, aphids, and rusts and other fungal diseases)
5.	Need to sell grain early because of lack of cash to pay taxes/input loans or to avoid storage problems
6.	Storage problems (primarily insect pests, but also termites, rodents and mould damage)
7.	Shortage of oxen (for ploughing and threshing)
8.	Soil erosion
9.	Shortage of grazing land
10.	Diseases of livestock
11.	Wild animals damaging crops
12.	Lack of pesticides and herbicides
13.	Lodging of maize and t'eff
14.	General poverty

Among the various post-harvest operations, the most important constraint was insect infestation in storage. A common coping strategy is to sell grain in order to avoid high losses to insects, and then to buy grain later (but at a higher price) as it is required. Mould damage can sometimes be serious; especially when there is unseasonable rain at harvest time or when grain is stored in underground (pit) stores. Losses during harvesting, threshing and drying were reportedly usually reasonably well contained, given timely availability of labour, and oxen for threshing.

A prerequisite to the identification of cost-effective methods of loss reduction is an assessment of the scale of losses - the objective of the main survey. However, even at this preliminary stage, there were indications that the introduction of a loss reduction programme might be justified. Pressure on farmers to find cash to pay taxes and production input loans and the fear of insect infestation in stored grain were the main reasons given by farmers for selling grain soon after harvest. Such early sales at low prices (often below the cost of production) deny farmers the opportunity of adding value to their production through sales later in the season at higher prices and of increasing household food security through retention of higher levels of grain stocks on the farm.

Lack of knowledge amongst farmers about storage insecticides and the poor availability of pesticides generally, particularly in the rural areas, are important constraints. To some extent, these constraints have been addressed through a relatively new storage improvement programme, piloted by the NGO, Sasakawa Global 2000 (SG2000) and recently taken up by the MoA in parts of Amhara, Oromiya and Southern Regions. The main thrust of the programme is the introduction of improved storage structures (mud-plastered baskets, fitted with loading door and outlet spouts, and raised on a rodent-proof platform) although the provision of storage insecticides is included in the package (see Annex 2).

METHODS OF STORAGE

Four main methods of storage were identified: (a) cribs or platforms for storage of cob maize and unthreshed sorghum; (b) outdoor containers made from mud plaster, or baskets, with thatched roof and usually raised off the ground on stones or a wooden platform (*gotera*); (c) mud-plaster bins kept inside the house (*gota*); and (d) underground pits. Small quantities of grain were found in a variety of small containers (sacks, bins, tins, boxes) kept inside the house. The *gotera* is used for storage of shelled grain and for maize on the cob whereas the *gota* is used almost exclusively for storage of shelled grain. Cribs/platforms, *gotera* and *gota* were found in all areas, but underground pit storage was restricted to the eastern part of Amhara Region (N & S Wollo, Oromyia and N Shoa Zones). Pit storage is used mainly for sorghum, but occasionally maize may be stored underground.

Grain may not be stored immediately after harvesting. For example, wheat and barley is often stacked in the field for several weeks until there is sufficient labour or animal power for threshing. Harvested sorghum heads and maize cobs are sometimes stacked in the field before being transferred to the homestead for immediate storage or threshing/shelling and storage. In West Gojam Zone of Amhara Region, maize cobs were often kept for 1-3 months in a crib or crib-like structure before being shelled and transferred to another store.

LOSS ASSESSMENT METHODOLOGY

Based on the findings of the preliminary survey, it was decided that the main survey should focus upon the assessment of losses in storage, and in particular losses due to insects and moulds. Although storage losses due to rodents can sometimes be serious, techniques for assessing such losses are expensive and time consuming. Moreover, it is arguable whether figures for loss of stored grain are needed. Losses of stored grain to rodents may be relatively insignificant when compared to the loss and damage they may cause to personal property or storage containers and the potential public health risks that they pose. If it can be established from a general survey that a rodent problem exists and that it is regarded as important by the community, then this may be sufficient to justify the introduction of a control programme.

Sampling of farmers' stores was carried out on two occasions: first, within the first month of storage and again later in the season. Wherever possible, the second samples were collected from the same store from which the first sample was taken. However, if this was not possible (e.g. because the farmer was not available at the second visit or, more usually, because all the grain had been used) a sample was collected from a substitute store.

Questionnaires were completed on both occasions. At the first visit, information was sought on the following: the history and pre-storage treatment of the grain; the size, construction and cost of the store; treatment of the grain for storage; the proposed use of the grain and expected pattern of removal; and the farmer's assessment of the advantages and disadvantages of the storage structure. The second questionnaire was designed to confirm details of the storage structure, quantities of grain stored and any treatment of the grain (use of insecticide, cleaning, re-drying etc.), and to gather information about the pattern of removal and grain use.

Samples were analysed to determine the percentage damage due to insects and mould and to assess the weight loss using the 'count and weigh' technique. The loss recorded in individual samples was related to the pattern of grain consumption to derive cumulative figures for losses over the storage season (Boxall 1986).

The 'count and weigh' technique provides a figure for the loss in weight caused by insect feeding or the development of mould, but this does not always reflect the loss as experienced by the farmer or consumer. It was observed that grain was always cleaned before use and that grains damaged by insects or mould were usually discarded as being unfit for consumption. Thus, these rejected grains should be considered as a loss of food, although they may have a secondary use as poultry or animal feed or may be used for brewing. Under these circumstances, losses measured by the 'count and weigh' technique would underestimate the loss of food grain suffered by the farm household. It was therefore decided that it would be more appropriate to equate the percentage damage with the percentage of food lost.

This approach was adopted for assessing losses in the smaller grains (sorghum, wheat and barley). However, the situation is rather different with the larger grains. In the case of maize and beans, heavily damaged grains (maize grains that have been completely hollowed out or beans with many holes) may be rejected as unfit for consumption and thus, the percentage damage again provides a useful indicator of the loss. However, at low levels of damage all the grains may still be processed and consumed, in which case it was more appropriate to use the weight loss figure derived from the 'count and weigh' technique.

Estimation of losses in maize in West Gojam Zone of Amhara Region especially, was complicated by the farmers' practice of storing cobs for several months before shelling. The first samples were collected from the cob-stored maize but at the time of the second sampling it was often found that the maize had been shelled. It is common practice to sort the grain at shelling and to reject damaged cobs or to set them aside for immediate use. Moreover, the shelled maize is usually cleaned to remove foreign matter and damaged grains before it is put into store. No records of this 'lost' grain were obtained; hence the figures obtained from this area may underestimate the loss.

FARM-LEVEL STORAGE LOSSES

Estimates of storage loss due to insects and mould damage were derived for each crop and for each Region (table 3). These figures reflect the situation in one (unusual) crop season, when production in some areas was severely affected by unseasonable rains

Table 3: Storage losses (%) by crop in Amhara, Oromyia and Southern Regions of Ethiopia

	Amhara Region			Oromyia Region			Southern Region			Total		
Crop	Insects	Mould	Total	Insects	Mould	Total	Insects	Mould	Total	Insects	Mould	Total
Maize	3.9	5.2	9.1	6.0	6.6	12.6	7.6	2.5	10.1	6.1	5.1	11.2
Sorghum	4.9	8.9	13.8	4.0	0.5	4.5	0.9	1.0	1.9	4.0	4.1	8.1
Wheat	0.7	12.7[1]	13.4	0.2	2.5	2.7	n/s	n/s	n/s	0.5	5.7	6.2
Barley	0.1	2.3	2.4	<0.1	<0.1	<0.1	n/s	n/s	n/s	0.1	1.4	1.5
Beans	0.3	17.4[2]	17.7	5.5	12.4[2]	17.9	n/s	n/s	n/s	5.2	14.4	19.6

[1] Includes shrunken/discoloured grains and grains damaged by unseasonable rain and frost; not all would be discarded

[2] Includes samples with high proportion of discoloured beans as a result of untimely rain at harvest/drying; not all would be discarded

The quantities of grain stored were smaller than usual and the storage periods were short. Crop forecasts and interviews with MoA officials and farmers at the beginning of the study led to an expectation that storage periods would not extend beyond about 6 months because of the effects of the unseasonable rain. Although this was the case in the more severely affected areas of the country, in parts of the survey area there was some recovery of crops, especially at the higher altitudes in Ambo and Bako weredas of Oromiya Region. Maize was also less severely affected than was at first suspected. Average storage periods for the different crops are given in table 4.

Table 4: Average storage period for crops in the three regions during the season under study

Crop	Region	Average storage period (months)
Wheat	Amhara	5.7
	Oromiya	7.2
Barley	Amhara	5.9
	Oromiya	7.8*
Beans	Amhara	5.0
	Oromiya	6.6
Sorghum	Amhara	5.7
	Oromiya	6.2
	Southern	4.3
Maize	Amhara	7.8*
	Oromiya	7.4*
	Southern	8.4*

*Storage periods from farmers' estimates of when grain stocks would be exhausted

During the preliminary survey farmers reported that insect infestation might be expected to appear after 3-4 months storage and from then on, it would increase rapidly. Some instances of heavy insect infestation were recorded in the survey, but much of the grain had been used by the time the second sample was collected. Thus, only relatively small quantities of grain would be exposed to high levels of insect attack. In a 'normal' year, more grain would be vulnerable to insect attack and for longer periods; accordingly losses could be expected to be higher. The figures obtained in this study, therefore, should be regarded as representing the minimum loss (at least due to insects) that might occur in a normal crop year.

The loss figures in table 3 were used to derive a single estimate of loss for the three regions (table 5). This overall estimate (9%) was obtained by weighting the individual crop losses by the region's contribution of each crop (W_m W_s etc.) to the total production of maize, sorghum, wheat, barley and beans, in the three regions. Production figures were taken from the Central Statistical Authority's report for the 1996/97 *meher* season.

Table 5: Estimate of loss in peasant farm storage in Amhara, Oromiya and Southern Regions of Ethiopia - *Meher* Season 1997/98

Crop		Amhara Region		Oromiya Region		Southern Region		Total
Maize	W_m	0.09		0.26		0.06		
	Insect Loss	3.9	0.351	6.0	1.560	7.6	0.456	2.367
	Mould Loss	5.2	0.468	6.6	1.716	2.1	0.150	2.334
Sorghum	W_s	0.13		0.12		0.02		
	Insect Loss	4.9	0.637	4	0.480	0.9	0.018	1.135
	Mould Loss	8.9	1.157	0.5	0.060	1.0	0.020	1.237
Wheat	W_w	0.03		0.1		0.02		
	Insect Loss	0.7	0.021	0.2	0.02	0.5	0.01	0.051
	Mould Loss	12.7	0.381	2.5	0.25	5.7	0.114	0.745
Barley	W_b	0.04		0.07		0.01		
	Insect Loss	0.1	0.004	0	0	0.1	0.001	0.005
	Mould Loss	2.3	0.092	0	0	1.4	0.014	0.106
Beans	W_{be}	0.02		0.02		0.01		
	Insect Loss	0.3	0.006	5.5	0.11	5.2	0.052	0.168
	Mould Loss	17.4	0.348	12.4	0.248	14.4	0.144	0.740
Total	Insect Loss		1.019		2.17		0.537	3.726 (= 4.0)
	Mould Loss		2.446		2.274		0.442	5.162 (= 5.0)
Grand Total								**8.89 (=9.0)**

W_m, W_s W_w, W_b W_{be} = weight representing contribution of each crop to total production of the five crops within the three regions

Wheat and barley

Losses due to insects (mainly *Sitophilus* sp) in wheat and barley were very low (averaging less than 1%). These crops are typically grown at the higher altitudes, where insect activity is low. Indeed, many farmers reported that they took advantage of low night time temperatures at harvest time to cool their grain by spreading it in thin layers on the ground before storage, specifically to discourage insect activity. In some areas e.g. Laygaint (South Gonder Zone of Amhara Region), the wheat and barley crop was seriously affected by the unseasonable rain and/or frosts this year and farmers had less grain to store. Consequently much of the grain was used before the warmer weather when insect activity is expected to increase.

Mould damage is rarely a problem in wheat and barley except when farmers have difficulty in drying because of untimely rain at harvesting. This was the case in some areas this season. In West Gojam Zone, particularly high levels of mould damage were recorded. However, in West Gojam, and to a lesser extent in other regions, the wheat was affected by a shortage of rain during the growing period with the result that the harvested crop contained many shrivelled grains. Some enumerators included these shrivelled grains and others affected by frost damage with the mould-damaged grains. Thus, the extent of loss due to mould damage will have been slightly overestimated. However, since a high proportion of such grains would be rejected as unfit for consumption they should, perhaps, be considered as a loss.

Beans

Insect infestation in beans (by *Callosobruchus* sp) was very variable, with losses recorded in samples ranging from less than 1% to 17.5%. The bean crop in Ethiopia has suffered from heavy field pest attack, especially from aphids, and fungal diseases during recent years. Consequently many farmers are reducing their level of production. Few households were storing beans and then often only in small quantities (100-250kg). Some households used the beans within the first 3-4 months of storage and so only very small quantities were likely to be exposed to insect attack.

Mould damage in beans is rare, occurring only when there is rain at harvest time. This was the case in some survey areas, particularly around Arsi Negeli in Oromyia Region, where piles of damp, unthreshed beans, showing visible mould damage were seen in November. However, beans tended to suffer the effects of unseasonable rain in the same way as wheat and barley. Some samples contained high proportions of shrunken beans, and discoloured grains were common. The most severely affected of these were put into the same class as mould damaged beans. It is debatable whether they would have been rejected as unfit for consumption and therefore considered as a loss. The poorer households whose overall production had been severely affected by the unseasonable rain would be unlikely to reject the beans whereas their more fortunate neighbours would be able to exercise a greater degree of selection.

Sorghum

Sorghum stored on the head on platforms remained in good condition, whereas the threshed grain was more susceptible to attack by insects (mainly weevils, *Sitophilus* sp). Farmers reported that the traditional varieties were generally less susceptible to insect attack and observations in the field tended to bear this out. However, there were insufficient 'improved' varieties in the sample to demonstrate clearly such higher levels of loss.

Sorghum stored in underground pits was severely affected by mould damage. If one were to view this mouldy grain as being unfit for consumption and, therefore, a loss of food, losses in sorghum would be of the order of 90-95%. Damage levels of this magnitude were recorded in sorghum that had been in pit stores for only 4-6 weeks. This early onset of mould damage may be unusual, in view of the rain at harvest and the subsequent difficulties that many farmers faced in drying their grain this season. Mould damage is regarded by local farmers as more of an inconvenience than a loss, since all the grain will be used for food or for brewing after washing to remove visible mould. Mould damage was less of a problem in sorghum stored in above ground structures and in such cases any mould-damaged grain would be separated as the grain was prepared for food. The estimates of mould loss for sorghum are based partly on percentage damage (grain discarded or rejected) and partly on weight loss (determined by the 'count and weigh' technique) particularly in the case of pit-stored grain.

Maize

Insect infestation in maize was extremely variable. It was evident that cobs were attacked in the field by weevils *(Sitophilus* sp) and moths *(Sitotroga cerealella)*. As in the case of sorghum, observation tended to confirm farmers' statements that the local varieties (with better husk cover and harder grains) were less susceptible to damage than the improved ones. This was verified by the loss estimates obtained in the survey .3.5% for local varieties and 7.9% for improved varieties.

Mould damage was most common when maize cobs were harvested in the rain, or when stacked cobs were exposed to untimely rain. A relatively high proportion of the severely damaged cobs were sorted out for immediate use or discarded as the cobs were put into store. Further separation of damaged grains took place as cobs were shelled. However, no estimates of this 'lost' grain could be made.

OPPORTUNITIES FOR STORAGE LOSS REDUCTION

Insect loss

Farmers regard insect infestation as the most important storage problem. Storage insecticides are not widely available and so farmers use a range of traditional methods of control or devise strategies to cope with insect infestation The most common traditional treatments described by farmers to limit insect activity are given in table 6.

Although the distribution and availability of storage insecticides is generally poor away from the main towns, demand amongst farmers is high. This was exemplified by the number of farmers who, when questioned about use of insecticides, reported that they would use storage insecticides if available, or that they regularly obtained insecticides from malaria control teams.

The correct use of appropriate storage insecticides has been promoted as part of the post-harvest activities of the Sasakawa Global 2000 project. Storage insecticides (mainly Actellic 2% dust) are made available to farmers participating in the improved storage programme (see Annex 2). This programme has recently been adopted by the Ministry of Agriculture and is being promoted nation-wide. In an attempt to improve availability of insecticide, limited stocks of Actellic 2% dust are now being held at the Wereda Agricultural Development Offices. However, it is reported that supplies are often received late and demand usually outstrips supply.

Table 6: Traditional methods for reducing or controlling insect infestation in stored grain

Pre-storage treatment
Selection of insect-free maize cobs at harvest or storage Winnowing and screening of shelled/threshed grain Sun drying of grain spread in thin layers on the ground Exposure of grain to low night-time temperatures (spread in thin layers on the ground)
Storage structure site/design
Siting storage structures outside the house in well ventilated areas Plastering walls with mud to prevent insects entering
Treatment of grain, physical barriers
Mixing plant materials or extracts with stored grain Treating grain with cattle urine Admixture of inert materials (wood ash, sand etc.) Exposure of grain to the smoke from cooking fires (especially seed grain) Mixing small and large grains (t'eff with sorghum and maize) Use of sealed containers (with limited opening) Mix improved with local variety
Physical methods after storage
Spreading grain in the sun at intervals Periodic winnowing and screening Warming small batches of grain over the heat of fire Transferring grain from container to container (to cool, sun-dry or to select uninfested grain)
Coping strategies
Consume more grain in early months before insect attack begins Early sale to avoid loss and damage to grain by insects

The benefits of treating grain with storage insecticides were clearly demonstrated in this survey. In West Gojam Zone of Amhara Region a comparison of the losses in insecticide treated and untreated maize stores was possible. The average loss in treated and untreated stores was 0.4% and 5.5% respectively. The difference (5.1%) represents the *minimum reducible* loss. Untreated maize is unlikely to remain in store for the full season; farmers will remove grain if it is thought that there is a risk of heavy insect attack. Thus, the potential loss in untreated grain can be expected to be greater than 5.5%.

Many of the farmers interviewed in Phase II confirmed that losses due to insects may be so severe and the traditional methods of control ineffective that they have no option but to sell their grain early and then to buy grain for consumption later in the season at higher prices. This imposes an additional financial burden on farmers who are already under pressure to sell produce early in order to raise cash to repay production loans, pay taxes or to meet seasonal expenses such as school fees.

Maize and sorghum producers and wheat producers were found to have used 55- 60% and 45-50% of their grain respectively, by March (some 7-8 months before the next harvest). More grain sales were likely in April and May as insect infestation was expected to increase significantly at this time. Grain prices vary considerably throughout the country and resources did not permit a study of the economic consequences for farmers of early grain sales. Moreover, information on grain prices is somewhat limited. The most reliable data are those prepared by the Grain Marketing Research Project (GMRP). A time series of wholesale and retail prices for a limited range of crops including white sorghum, white maize and white wheat at a selection of 20+ markets, and information on producer prices are available from August 1996. Some data on historical price trends are also available. However, the information on the nature of price relationships among producers, wholesalers and retailers is limited, since studies on the impact of market liberalisation have been restricted to the wholesale level.

Notwithstanding, an indication of the potential financial benefits of treating grain with an insecticide and thus avoiding early sales can be obtained by reference to the average price data for cereal crops at 26 markets obtained by the Grain Market Research Project (see table 7).

Table 7: Average grain prices (Ethiopia Birr/quintal) at three points during the season (1996 -1997)

	November/December	April/May	August/September
Wheat	110	140	183
Sorghum	96	104	162
Maize	66	74	123

Source: Grain Market Research Project (Market Information Bulletins)

Mould loss

Mould damage is most serious in grain stored in underground pits. Farmers confirmed that grain stored underground was invariably affected by mould and that the level of damage depended on whether or not the pit was filled completely and on the frequency of opening. Damage may be minimal in pits that are completely full and remain undisturbed for long periods but will be greater in partially filled pits.

Frequent opening to remove grain tends to result in higher levels of damage. These observations are in keeping with earlier experimental studies (Boxall, 1974).

Consumption of mould damaged grain is undesirable, and so, it is common when assessing losses, to equate the percentage of mould damage with percentage loss. Although farmers may not regard mould-damaged grain as a loss, they are nonetheless interested in finding ways of reducing such damage. For example, linings of plastic sheet, straw and sorghum stalks are sometimes used in pit stores in an attempt to reduce the amount of mould affected grain.

Underground storage is traditional in N & S Wollo and in the past, damage may not have been so severe as it is now. It was reported that pits were usually filled completely but this is becoming less common, especially as the size of individual land-holdings decreases. Some large pits that used to be filled completely are still in use but they cannot possibly be filled given the yields obtained from small land holdings. Some farmers have given up underground storage and have adopted the *gotera* or more commonly the *gota*. If this practice could be encouraged, there is clearly an opportunity to reduce the amount of grain that would be vulnerable to mould damage. Many farmers continue to use pits claiming that the grain is more secure than when stored above ground. Hence there remains a need to identify methods that might limit mould damage in pits.

Pit storage is not restricted to N & S Wollo; it is the predominant method of storage in Eastern Ethiopia (E & W Harraghe Zones of Oromia Region and in Somali Region). Studies conducted in the 1970s and 1980s led to limited success in using a variety of linings (straw, plastic, cement plaster and concrete) to reduce mould damage (Boxall, 1974; Lynch *et* a!, 1986). However, some linings, especially those involving the use of cement, were often too expensive for all but the wealthiest of farmers. Recently, the SG 2000 post-harvest project has begun an investigation of ways to improve underground pit stores and it proposes to take forward the earlier 1970s and 1980s work on linings.

POST-HARVEST LOSSES OTHER THAN IN FARM STORAGE

This study has focused upon losses in farm storage since this is an area in which it is felt that a significant impact in loss reduction might be made. However, it is evident that losses occur in other parts of the system and these are addressed briefly below. Moreover, in view of the interest being shown in post-harvest losses and their reduction by a number of organisations in Ethiopia, not least by the Regional Bureaux of Agriculture in their Draft Integrated Food Security Programmes, an attempt is made here to predict an overall level of post-harvest losses in Ethiopia and to further demonstrate the importance of losses in farm-level storage.

Harvesting/threshing

There is an optimum time for harvesting when immature grains, losses due to shedding/shattering of mature grains and weather damage will be minimal. If the crop is harvested too early there will be a high proportion of immature grains which is undesirable. If harvesting is delayed, mature grains may be attacked by insect pests and microorganisms or may be physically lost through shedding or shattering. The method of harvesting and the skill of the harvester (especially when crops are harvested mechanically) will also affect the level of shattering losses.

Losses during threshing may arise through incomplete threshing (loss of grain on the straw) and scattering or spillage during the operation. Physical damage (chipping or breakage of the grain) may also occur, resulting in a poor quality product. Again the method of threshing and the skill of the operator will directly affect the level of loss at this stage.

Hand harvesting and threshing is widespread in Ethiopia and, although there has been no study of these losses, common opinion is that they are generally well contained within acceptable limits. Much of the spilt grain may be gleaned from the field or the threshing floor, but there may still be room for some reduction in losses. More important, perhaps is the damage caused to grains during threshing. Broken grains may be screened out and lost. If taken into store they may encourage insect development since they will be more susceptible to pest attack.

Contract combine harvesting is becoming more common in some areas of Ethiopia and this is reported to lead to higher levels of loss and damage. The use of combine harvesters is only worthwhile where large areas can be harvested at once. It is therefore common practice for farmers to group together to arrange for their fields to be harvested at the same time. Those that wish to take advantage of the contract harvesting service may face a dilemma if they are not to miss out. Some may have to harvest earlier than they would wish whilst others may have to delay harvesting and risk higher shedding losses. The alternative would be pass up the opportunity of the combine harvesting service and to harvest at the optimum time by hand. Even then there may be insufficient labour available to ensure timely harvesting and insufficient labour or animal power for threshing. Some concern has been expressed both by farmers and MoA officials over the loss and damage to grain associated with contract combine harvesting, but no studies have been undertaken to assess this problem.

Trader storage

Storage capacity in assembling markets is reported to have increased since the market was liberalised in 1990, yet a high proportion of traders claim to have inadequate storage facilities in terms of availability, storage space and location. Moreover, storage facilities are reported to be vulnerable to damage caused by moisture, and rodents (Dessalegn *et al* 1998).

It is estimated that 80% of traders hold grain stocks for up to 6 months. Bag storage is common although some traders store in bulk. Weight losses during storage are variable and have been estimated to be 3.3% for maize, 2.1% for wheat and 2.4% for t'eff. However, losses vary with length of storage and it is estimated that loss for t'eff ranges from 1.5% for grain stored for up to two moths and 4.2 % for grain stored for more than a year. The main causes of storage loss in order of importance are moisture, rodents and spillage (Dessalegn *et a!* 1998). The loss due to moisture is presumably due to grain drying out during storage. This factor is recognised in the trade and allowance is usually made for such changes (shrinkage). Strictly speaking, loss of moisture is not regarded as a loss of food material. There was no mention in the report of loss due to insect pests .perhaps because it is not considered important by traders or because it is kept in check by fumigation.

Transport

There has been no detailed study of losses in transport although Dessalegn *et a!* (1998) record that grain merchants reported weight losses in transport ranging from 0.1% to 16% with a mean of 2.2%. No explanation was given of the likely causes of this loss.

Estimate of total post-harvest losses in Ethiopia

An attempt has been made to derive a figure for the total amount of grain lost after harvest in Ethiopia and to highlight the importance of farm storage losses (table 8). The figures used in this calculation have been derived from various sources. Production figures are from the CSA records for *1995/96* and include cereals, pulses and oilseeds; estimates of the proportion contributed by State farms and peasant farms are from CSA and GMRP data; and the estimates of the proportion that each group contributes to the total marketed quantity are base on figures from the GMRP (Central Statistical Authority, 1997; Dessalegn *et a!,* 1998). Farm storage loss estimates are based on figures obtained from the present study. Figures for losses for other stages of the post-harvest system are 'best guesses' based on published and unpublished information, field observations and information gathered from interviews and informal discussions with farmers, MoA officials and researchers.

It is interesting to note that the overall figure for post harvest loss of 10.9 (11%), equivalent to just over 1 million tonnes of grain, corresponds closely to Loerbroks (1994) estimate. Loerbroks stressed the need to reduce post-harvest losses yet could foresee reductions of only 1-2% every *5* years. He gave no indication of where in the post-harvest system these losses were occurring and, therefore, gave no guidance on where best to intervene. The figures in table 8 show that, of the 1 million tons or so of grain lost after harvest, more than half is lost during storage on peasant farms. This quantity (of around 580,000 tonnes) is similar to the DPPC's 1997 estimate of the amount of food required for people in immediate need of assistance. Post-harvest improvement programmes that target peasant farmer storage can therefore be expected to achieve a significant impact in reducing losses, increasing farm incomes and improving rural household food security.

Table 8: Post-harvest losses in Ethiopia

Total Domestic Grain Production = 9,430,000 t					
State farm production (1.6%) = 150,800 t			Peasant farmers' production (98.4%) = 9,279,120 t		
Loss at harvesting and threshing (3%)	4,524 t		Loss at harvesting and threshing (3%)	278,374 t	
Balance	146,276 t		Balance	9,000,746 t	
	Sale (90%) 132,000 t	Storage (10%) 14,276 t		Sale (28%) 2,508,000 t	Storage (72%) 6,492,746 t
Transport loss (2%) Balance	2,640 t 129,360 t		Transport loss (2%) Balance	50,160 t 2,457,840 t	
Storage loss Traders (4%)	5,174 t		Storage loss (4%) Traders	98,314 t	
Storage loss Farms (4.5%)		642 t	Storage loss (9%) Farmers		584,347 t
Total available to consumers	124,186 t	13,634 t		2,359,526 t	5,908,399 t
Grand total available to consumers = 8,405,745 t			**Total Post-harvest Loss = 1,024,255 t** **of which Farm Storage Loss = 584,347t**		**10.9%** **6.2%**

PROJECT WORKSHOP

The project made provision for a workshop to review the organisation and findings of the survey, to discuss future action and to assign priorities. The meeting was held at the EARO Crop Protection Research Centre, Ambo. It was attended by crop protection researchers (EARO), representatives from the Crop Protection Divisions of the three Regional Agricultural Bureaux, Post-harvest Experts from the Amhara Region Plant Health Clinics, Zonal and Wereda-level Crop Protection and/or Post-harvest Team Leaders, and Development Agents from selected sample areas in the three Regions.

The workshop endorsed the survey procedures and confirmed the research findings. It also agreed that the loss figures, together with the results of the farmer interviews, provided sufficient justification to move towards developing and implementing a storage loss reduction programme. Senior MoA staff pointed out that the study was timely since emphasis is being given to reduction of post-harvest losses in the Integrated Food Security Programmes that are currently being drafted by the Regional Agricultural Bureaux.

The reasons for the relatively short period of the study were accepted, although there was some concern that results were based on just two sample periods. It was suggested that the loss figures might be refined if the grain that is likely to remain in store for a further three months or more could be sampled for a third time (in June). It was accepted that results from a third round of sampling may not alter the loss figures significantly, rather they might be expected to confirm that the original figures are of the right order of magnitude. The Ethiopian team members were to look into the possibility of conducting this further round of sampling. If it can be accomplished the results will be sent to NRI and the revised estimate could issue as a supplement to this report.

There was considerable discussion about the ranking of agricultural problems and the importance of post-harvest (especially storage) problems (see page 5). Participants, representing 14 different locations throughout the sample area, were asked to reconsider the list of constraints and to re-rank them in order of their own perceived importance for their particular area. In all but two cases storage problems were given a higher ranking (table 9).

Table 9: Numbers of individuals ranking storage as being more important than in the farmers' assessment. (Original rank for storage = 6)

Rank	1	2	3	4	5	6	7
No. Scoring	2	2	4	4	0	1	1

The main discussion of the workshop addressed priorities for future action. It was unanimously agreed that more could be done to reduce storage losses if: (a) post-harvest activities were given greater priority in the work programme of Development Agents; and (b) there was greater awareness of post-harvest problems and their solutions.

The most pressing need is for a significant improvement of post-harvest training at all levels, including agricultural schools, university undergraduate courses and MoA basic training for Development Agents. The training should have two objectives, namely: raising awareness of post-harvest problems and the potential savings of food that might be achieved and, equipping front line staff (and their supervisors) to address storage problems.

Most DAs commented that they received so little training in post-harvest matters and no supporting reference information, that they were reluctant to raise the subject with farmers. It was remarked that farmers probably knew more about the subject than some DAs. The SG 2000 programme has provided some post-harvest training for DAs and it was noted that a new SG 2000 post-harvest training manual was about to issue. The training was appreciated, but it was noted that it was mainly linked to the promotion of the improved storage structures. It was felt that DAs should be equipped to make an assessment of farmers' problems and to identify solutions appropriate to the individuals' situations rather than to deliver a single message on storage improvement. This type of participatory approach to extension work is being encouraged in other sectors and it would be timely to consider developing a similar approach for the post-harvest sector.

As far as extension messages are concerned, there is a need to promote a basic message of good storage practice, including use of storage insecticides. However, it was recognised that the impact of such a message would be reduced unless greater efforts were made to improve the supply of storage insecticides, especially in the more remote rural areas.

The SG 2000 improved stores have been introduced successfully in several areas of the country and the MoA is now promoting them. However, the structures are relatively expensive and it is only the more wealthy farmers or those who have access to credit facilities (arranged through SG 2000 and more recently through MoA) that can afford them. The meeting agreed that there were opportunities for the identification and introduction of low cost improvements to traditional storage structures as alternatives to the SG 2000 design.

It was noted that work on developing improved grain stores has focused on the traditional outdoor bin or basket structure (the *gotera).* There seems to be little opportunity for improving the indoor bin *(gota).* However, in some parts of the country, notably N and S Wollo and Harrarghe, underground storage is widespread and in this system grain is often severely damaged by mould. SG 2000 is considering a programme to *improve* pit storage and it was recommended that this topic be given a high priority. As well as using linings in pits to reduce mould damage consideration should also be given to.persuading farmers to adopt an above ground storage system. Little information is available about the health risks associated with the consumption of mould damaged grain from underground stores and it was suggested that an investigation be undertaken, especially as the populations using underground storage are commonly malnourished and at risk from food grain shortages.

Concern was expressed that it may take some time for a reliable insecticide distribution network to be established and that some farmers may be unable to afford them or simply may choose not to use them. It was noted that a wide range of naturally occurring materials are used as grain protectants and that various stations of the EARO have on-going programmes concerned with the laboratory-scale evaluation of such materials. It was therefore suggested that the current investigations of the efficacy of indigenous materials (dusts, ashes and plant materials) as grain protectants be better co-ordinated and extended to field-scale trials.

The new production package programmes for cereals (improved seed, fertiliser etc.) introduced by SG 2000 and now being implemented by MoA are boosting production. For example, average maize yields have more than doubled from 1.8t/ha using conventional production methods to 5.7 t/ha using the 'package' (Anon, 1996). This additional production places a strain on traditional post-harvest handling and storage, and farmers need assistance and guidance. For example, on how best to cope with shelling and storing the increased maize production. Traditionally, maize is shelled by hand or by beating with sticks. This is time consuming and labour intensive and creates an additional demand on family and communal labour. What options are open to the farmer? If maize cannot be shelled quickly, how long can maize be stored on the cob; what are the risks involved and what changes in storage management might be required, especially when improved varieties are more susceptible to pest attack.?

Small-scale mechanical shellers are being developed and introduced in some areas and this may be a solution to the shelling problem. However, it is reported that some machines result in products with high levels of broken grains which will have a lower market value. It was therefore proposed that the costs and benefits of small-scale threshers be thoroughly investigated before they are introduced on a wide scale.

CONCLUSIONS

This loss assessment exercise was conducted in a year when crop production in Ethiopia was adversely affected by unseasonable rainfall. Farmers in some areas experienced significant reductions in crop yields and others faced difficulties in handling and storing wet produce due to the rain at harvest time. The combined effects of low yields, early sales of grain to avoid the difficulties of handling a wet harvest and additional sales to meet input credit repayments, meant that less grain was stored and for a shorter period. Notwithstanding, the project demonstrated that storage losses due to insects and moulds are of the order of 9%.

The project also confirmed that farmers regard storage losses as an important problem. Given the unusual circumstances this season, the figure of 9% should be regarded as a minimum loss. Higher losses can be expected when larger quantities of grain are stored; stocks will last longer and more produce will be exposed to damage, especially by insects, for longer periods.

The importance of on-farm storage losses becomes more apparent when viewed in relation to national food grain supplies. It has been estimated that the losses are likely to account for more than half of all post-harvest losses of grains. Given an average annual grain production of 9.5 million tonnes, farm-level storage losses will be around 580,000 tonnes. This is equivalent to about one and a half times the current stock level of the Ethiopian Food Security Reserve or the estimated food requirements for people deemed by the DPPC to be in need of immediate assistance in 1997/98.

Seen in this context, the loss estimates for farm storage clearly justify the implementation of loss reduction programmes. Although no detailed study has been made of the losses occurring during the pre-storage activities it would appear that these too may be significant and amenable to reduction. Further studies are needed to obtain precise estimates and to identify where or how to intervene. However, since the extent of loss in storage can be related to the condition of grain entering the store (the level of damaged or broken grain and foreign matter resulting from harvesting, threshing, drying etc.) such studies are best incorporated as part of any programme that primarily address storage problems.

At present, much emphasis is being placed on improving food security through increased crop production using the 'package' of improved seed, fertiliser and extension advice, piloted by the Sasakawa Global 2000 programme. The new high-yielding varieties of grains that are being promoted are more susceptible to pest attack after harvest and unless there is timely intervention, storage losses can be expected to increase well beyond the 9% level recorded by this project.

Insect infestation in stored grain is regarded by farmers as an important problem and many traditional methods are employed to try to reduce damage. These may be largely ineffective and farmers often resort to early sale of produce (at low prices) to avoid insect damage. Thus, they are denied the opportunity of adding value to their production through sales late in the season at higher prices and of increasing food security through retention of increased production on the farm.

The project found that significant reductions in the loss caused by insects can be achieved through use of insecticides (losses recorded in untreated and treated maize were 5.5% and 0.4% respectively) and that farmers will store treated grain for longer periods to benefit from seasonal price rises. However, distribution of agricultural chemicals generally is poor and storage insecticides are rarely available outside the major towns. The Ministry of Agriculture is attempting to improve distribution of insecticides by holding stocks at Wereda offices, but the private sector must be encouraged to more actively promote use of storage insecticides and improve distribution.

The use of traditional materials to control insect infestation is widespread, and undoubtedly, some are quite effective. Laboratory investigations into the use of some of these materials are being undertaken at a number of research institutes but the work is largely uncoordinated and some duplication of effort is inevitable. In view of the possible advantages of achieving a good degree of control with such materials, the research work needs to be better co-ordinated and should move quickly towards the testing of promising materials in farm-level trials.

Mould damage is an important problem in grain stored in underground pits, although farmers feel that this is something they have to live with. Damage can be severe (90% of grains affected by mould within a month or two of storing) resulting in weight losses of up to 10% over a season. Reduction of losses caused by mould growth on grain stored in underground pits is difficult but might be achieved by the use of pit linings that restrict moisture and the subsequent development of mould. The SG 2000 post-harvest programme has recently expressed interest in addressing the issue of improving pit storage. However, some farmers have given up pit storage and now store grain in traditional basket-type structures. It would, therefore, be appropriate for programmes addressing the problem of mould damage in pit storage to consider the option of above ground storage as an alternative to using lined pits.

Mould damage will reduce the nutritional value of grain but perhaps more serious are the health risks associated with consumption of mould damaged grain that may contain mycotoxins (even after the visible mould has been removed). The possibility that mycotoxins (particularly aflatoxin) might be associated with the high level of hepatoma in parts of Africa, including Ethiopia was well reviewed over thirty years ago (Coady, 1965; Oettlé, 1965). However, mycotoxins are also known to affect the human immune system and thus increase the risk of contracting infectious diseases. Little is known about the incidence of mycotoxins in stored grain in Ethiopia and a survey, especially of food products derived from grain stored underground, is required to establish more precisely the risk faced by rural consumers. Such a survey might also be extended to those urban areas where pit-stored grain is marketed. The results of the survey may provide further justification to persuade farmers to find alternatives to underground storage of grain.

Little attention had been given post-harvest extension until SG 2000 began to promote improved storage structures in 1995. Extension workers received some basic post-harvest training, but this was really linked to the construction and management of improved stores. Demand for improved stores is increasing, especially now that the SG 2000 package (including credit facilities for store construction) is being taken up by the Ministry of Agriculture. The major benefits of the structure are that ground moisture damage and rodent damage to produce is minimised. Mud-plastered walls may restrict entry of insects but insect control depends on the use of insecticides which are supplied as part of the 'package'. The structure is not suitable for all farmers (too expensive) or all areas (shortage of locally available construction materials). SG2000 arranged supply and transport of construction materials, at least for its demonstration stores, but it is difficult to see how the MoA can provide this service. More effort is needed to find low-cost or no-cost improvements to traditional stores that overcome problems of moisture and rodents and to make storage insecticides more widely available.

It is evident from interviews with Development Agents of the Extension Service in the field and reports from DAs attending the project workshop, that there is an urgent need to improve post-harvest training at all levels. The SG 2000 has gone some way to address this issue by preparing a basic training manual to support the 1-2 days training that is arranged for extension personnel. However, a case can be made for the immediate introduction of more extensive training courses for the Extension Service.

Although extension staff may be designated as 'post-harvest specialists' or 'post-harvest team leaders', in reality this may mean very little. It was obvious that individuals had little or, more usually, no specific training in the subject. A case can also be made for upgrading the post-harvest input to the standard nine-month training programme for extension personnel. It is reported that post-harvest issues are given scant coverage by both the agricultural schools and the university undergraduate courses. Improvement of training at these levels would ensure a future cadre of post-harvest specialists and trainers within the MoA and the extension service in particular. As a first step, a review might be undertaken to establish how the subject is being addressed in the various teaching/training establishments, to identify training needs (including training of trainers) and to develop appropriate curricula.

The Regional Agricultural Bureaux have declared their intention of attaching greater priority to post-harvest problems in the new Integrated Food Security Programmes that are currently being drafted. However, these documents provide very detail about proposed activities at this stage. From the foregoing it is clear that there are opportunities for the Bureaux to establish farm-level storage projects that incorporate:

- research (to identify options for addressing various storage problems);
- extension (of basic messages of good storage practice and later improved methods of storage); and
- training (both short term and long term, to strengthen the post-harvest capability of extesnion personnel).

Some suggested areas for further DFID support are given in Annex 3. These suggestions could form the basis of discreet projects or one or more might be combined as activities contributing to a broader project.

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