On-farm storage losses of cowpea in Northern Ghana.

Golob, P.[1], Andan, H.F.[2], Atarigiya, J.[2] and Tran, B.M.D.[1]

Abstract

It is well known that grain legumes are subject to heavy damage by bruchid beetles during storage. Many laboratory studies have demonstrated that *Callosobruchus maculatus* can develop rapidly in cowpea. There are, however, few studies demonstrating what actually happens to cowpea on farms during storage

This paper presents the results of surveys conducted in northern Ghana between 1997 and 1999 to identify the problems concerned with storing cowpeas. *C. maculatus* was the most important pest.

Cowpea was readily attacked although the weight loss resulting from infestation was rarely in excess of 9% even after six months storage. Farmers rarely used conventional insecticide to protect the grain but they did use a variety of alternative methods including admixture of ash and some plants. These methods appeared to provide some protection.

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[1] Natural Resources Institute, Central Avenue, Chatham Maritime, Kent, ME4 4TB, United Kingdom. Fax: +44 (0)1634 880066/77

[2] Ministry of Food and Agriculture, Accra, Ghana.

Introduction

Grain legumes are commonly used as dry seed for cooking in much of tropical Africa. They have a protein content of approximately 20 to 25% (McFarlane, 1983), and their nitrogen fixing ability helps to increase agricultural yields. Cowpea (*Vigna unguiculata* (L. Walp.) is the most important grain legume in Ghana. The mean area planted with tp pulses in Ghana was estimated in 1987-1989 to be in the region of 147,000 hectares, with the mean annual production of cowpeas being about 210,000 tonnes (Ghanaian Ministry of Food and Agriculture and Crops Research Institute, Kumasi, unpublished data). Cowpeas are grown throughout Ghana, but production is largely confined to the north of the country, in the Northern, Upper East and Upper West regions. Most farmers cultivate between 0.4 and 2 hectares of cowpea, which is often inter-cropped with cereals. In northern Ghana, cowpea forms a major part of the diet, and the majority of farmers cultivate it for subsistence, but some also sell part of the harvest.

Stored legumes are attacked by bruchids (Coleoptera: Bruchidae). The larval stages develop inside the beans; damage and weight loss are caused by larvae consuming the seed. *Callosobruchus maculatus* (Fab.) is the most important pest developing on cowpea. Experimental studies have shown that in the laboratory, female bruchids can lay in excess of 100 eggs, and with a generation time of about a month (Dick and Credland, 1984), infestations grow exponentially until the complete stock is destroyed, in a few months.

The levels of losses due to bruchids in Africa are not well documented, due partly to the lack of suitable verified methodologies for assessment. Gudrups (unpublished data) found cowpea with damage levels of 22-23% on average, in markets in Accra and Tamale in February and May 1995. In markets in northern Ghana, levels of damage varied from 15 to 94% for cowpea (Golob, unpublished data). On-farm damage has rarely been studied, losses even less. Caswell (1974) described on-farm losses for cowpea in northern Nigeria increasing from 4% soon after harvest to 60 to 70% at the end of the storage season.

Material and Methods

SURVEY

This survey of stored cowpea covered two regions of Ghana, Northern Region and Upper East Region over two years. Duting the first year, 1996-97, thirty-five farmers in one or two villages in each region were selected before harvest to participate in the study. Only farmers who intended to store for at least five months were chosen. Post-Harvest Officers (PHO) from the Ministry of Food and Agriculture made monthly visits to the farmers during the whole storage period (from December through to the following September), and recorded the treatments applied to protect the crop against the bruchids infestation.

At each visit these field staff recorded the quantities of grain removed from each store by directly questioning the family and by visually checking the log of grain removals. Household members (generally women) were requested to place a stone into a coloured plastic cup each time grain was removed from the store. One stone indicated the removal of one bowl, and cup colours corresponded to the type of removal, i.e. for sale, seeds, food or gifts. Each bowl was of a standard size, having a capacity of approximately 4.5 kg, and was the local unit used for measuring cowpea. When removals were made for sale the price obtained was also recorded.

PHOs also measured the damage caused by bruchids on two replicates samples of 200 grain. The damage data allowed calculation of weight losses, using a rapid method of assessment developed prior to the survey(Wright and Golob, in press) to allow fast, reliable on-farm assessments. The relationship between the two variables was investigated on samples collected from local markets, and covering a wide range of damage. The relationship was determined to be well represented by a second degree polynomial equation, which can be used in calculations, and a graph was produced, together with a simple protocol, for use in the field.

Due to the participatory nature of the survey, some data were incomplete. Such cases were not included in the analysis.

During the storage season 1997-98, a second survey covered 131 farmers, in 20 villages in four districts of the Northern Region alone. In this survey only insect damage was recorded, and used to calculate weight loss. As removals were not recorded, the figures illustrating damage and weight loss are simply sample estimates, and are not related to actual losses as were calculated for the previous year study.

DATA ANALYSIS

Damage and loss

The average percentage damage given here for the whole storage period are calculated by weighting the observed damage by the amount of beans removed at the time of measurement (i.e. monthly):

$$\text{Average \% damage} = \frac{\sum_{\text{over the whole storage}}^{\text{for each month}} (\text{removal x \%damage})}{\sum_{\text{over the whole storage}}^{\text{for each month}} (\text{removals})} \qquad \text{(equation 1)}$$

$$\text{Average \% weight loss} = \frac{\sum_{\text{over the whole storage}}^{\text{for each month}} (\text{removal x \%loss})}{\sum_{\text{over the whole storage}}^{\text{for each month}} (\text{removals})} \qquad \text{(equation 2)}$$

These figures are therefore representative of the actual damage in the grain removed, at the time of removal, taking into account the variation of the damage during the storage period and the removals of grain by the farmers. The percentage weight loss, calculated in the same way, is expressed in a manner which is relevant to the farmer.

Statistics

Where needed, percentages were normalised using an arcsine square root transformation. Mean and standard error of the mean were calculated, and are given as 'mean ± SEM'. Comparison of the mean values were made between pairs with ttests. For transformed data, reverse transformed percentages were then calculated for the means, and are also presented.

Results

Cowpeas were all local white varieties, those from Upper East had larger grains than those from Northern Region.

QUANTITIES STORED

The quantities of cowpea stored differed markedly between the two regions. In Northern Region, farmers stored on average 135 ± 22 bowls, whereas in Upper East Region the average was only 21 ± 2 bowls.

INSECT DAMAGE AND WEIGHT LOSS

Table 1 presents the average percentage damage and weight loss over one storage year (1996-97) in the two regions studied. The effects of bruchid attack were significantly greater for farmers in Northern Region. Figure 1 shows the evolution of the damage measured on cowpea in Northern Region over the whole period of storage during the second year (1997-98). In this second year, damage ranged from 2-100% with a mean of 25%, the pattern of increase being similar to that which occurred in the first year although values were slightly lower. These are the averages of the data collected monthly during the survey across the Region. The data are estimates on the samples collected.

In Northern Region, 89% of farmers suffered measurable weight losses, but in Upper East Region only 29% did. Calculation of weight loss could not be completed for those farmers whose grain exhibited very low levels of damage.

REMOVALS FROM THE STORES

Variation in time and use

Figure 2 shows the monthly removals over the storage period. Where possible, removals were classified either for sale or for a combination of uses for gifts, seed or food. This information was not available after May, in Upper East Region. From the stores in Northern Region, there was a slow increase in removals at first, then a peak in May and June, followed by a steep decrease. Almost the entire stock was sold during the storage period. In contrast, in Upper East Region, sales were less prevalent. Quantities removed decreased during the storage period, with the exception of a peak in May,when prices peaked; before May, sales represented only a small proportion of the removals.

Price variation

Figure 3 presents the average price obtained by the farmer, per bowl of commodity sold, each month. The number of sales is also shown. In Upper East Region, data were not available after May.

Sales in Northern Region were made at low prices, around 1500 cedis per bowl, and they remained rather constant until June. Prices fell to 1000 cedis in July and August, then rose again. In Upper East Region, prices were much higher, starting at 2000 cedis, and growing quickly to about 2700 from February to May.

PROTECTION METHODS USED

During the survey, the methods of protection used on the stored commodities were recorded. Globally, they differed according to the commodity, and to the region. Table 2 presents the methods of treatment used on cowpea, ranked according to the percentage damage suffered on the treated stock. The use of synthetic chemicals was comon in Northern Region most of the chemicals were on sale primarily to use as maize storage protectants. Some of the chemicals, for example cypermethrin, are not approved for use on raw grain whilst phosphine, although readily available and cheap is much too toxic to recommend to farmers to use. It is interesting to note that none of the respondants in Upper East Region used synthetics, instead they relied mostly on the addition of ash but, paradoxically, obtained the better control by far.

Discussion

The quantities stored reflect the use of the crop. In Northern Region, cowpea is grown primarily as a cash crop, and only secondarily as a food crop. The quantities stored are therefore substantially greater than in Upper East Region, where cowpea is mostly used as a food crop and farmers do not produce sufficient surplus for sale.

Much of the grain is stored throughout the season for use as seed. There is very little improved sed available for sale and most farmers tend to retain their own seed for future planting.

In Northern Region, sales occur mostly during the first half of the storage season, when the prices remain low as a result of continuous supply coming on to the market. The sales are made in the months after harvest to raise cash to meet debts (e.g. loans for fertiliser, the hire of tractors and labour and to pay school fees). This trend continued until the middle of the year when cowpea produced in southern Ghana started to appear in northern markets. Even in August prices did not pick up because early maturing varieties began to be harvested. Prices only rose in September and October, in the period immediately prior to the harvest of the main crop. The opposite situation was observed in Upper East Region, where demand even shortly after harvest caused prices to increasebecause of the reluctance of producers to sell.

In Northern Region, the need to sell early for want of cash is compounded by the inability to store cowpea without it being attacked by bruchids. Farmers are unable to store for long without incurring heavy grain damage because the protectants used do not appear to be very effective. Whether the poor protection is a direct result of using inappropriate chemicals or rather, and more likely, that the chemicals are misapplied needs to be confirmed.

The prices recorded in this survey are prices attained by the cowpea which was sold, not the maximum prices that good quality cowpea could fetch. Data from the

Ministry of Food and Agriculture show that between December and September, the increase in price for cowpea can be as much as 51% (I. Gudrups, unpublished data).

Weight losses were lower than might have been expected from laboratory investigation. This is partly due to the method of assessment, which takes into account the declining amount of food in the store as the storage season progresses, and calculates the losses on the beans removed from the stores by the farmers, i.e. the *actual* loss incurred. Few other estimates have done this, and these have, therefore, tended to over-estimate the actual losses.

The weight losses measured in this study appear to be of negligible importance, but the damage is certainly not, because damaged beans will command a much reduced price at market. Prices for cowpea are reduced if they are insect damaged. This explains why prices recorded for selling cowpea in Northern Region did not increase with time; grain was damaged soon after harvest and so the premium prices offered for undamaged grain could never be attained. At Tamale market, the main market in northern Ghana, good quality cowpea is bought at a premium price by traders from the south (up to 2600 cedis per bowl). Poor quality cowpea stays in Tamale and is retailed locally by women traders.

In May 1997, it was noted that the damage levels found in Northern Region were consistent with the development of only two generations of bruchids during six months storage. Also, in many cases, all adult bruchids found in the samples were dead, some inside the grain. Figure 1 shows that the damage to cowpea increased only until March or April. Although this could be related to the decreasing number of farmers who keep cowpea in store (it is likely that only farmers whose stock is not too badly damaged keep their beans), the typical increase of damage observed in the laboratory was not apparent on farms. It appears that populations of bruchids do not develop as quickly and dramatically in farm stores as they do under experimental conditions.

This survey lists several methods of used for the proection of cowpeas during storage. To illustrate the effects, the data were presented with the damage which occurred, but a causal effect cannot be inferred with certainty from this study, as there may be several other variables affecting grain damage (e.g. the initial level of infestation, misuse of insecticide and the type of storage structure used).

Admixture of ash appeared to be a widespread method of protection in Upper East Region, where all farmers included in the survey used ash on cowpea, at least as part of a treatment.

In Northern Region, cowpea stores at farm level are mainly treated with pesticides. There was no use of chemicals in Upper East Region on cowpea, where ash was generally added to the commodity. The availability of pesticides is a restricting factor for rural areas, as is the price of these chemicals. This would explain their widespread use only on cowpea in Northern Region, on commodities mainly destined to be sold on the market.

Untreated cowpea stocks suffered an average damage of 36% in Northern Region (table 2). The application of synthetic contact insecticides such as cypermethrin or Sumicombi (fenitrothion + fenvalerate) did not provide any measure of protection. This was probably because of poor application methods leading to underdosing and the use of poor quality formulations. Clearly, farmers and extension workers require much more training if they are to make best use of these chemicals.

During this survey, and previous studies in these areas, it was noted that aluminium phosphide tablets, from phosphine gas evolves, were used improperly. It does not only limit the efficacy of the fumigation, but is dangerous for farmers and their families, and could lead to development of resistance in the local strains of bruchids exposed to sub-lethal concentrations. Although it will be impossible to effectively prohibit the use of phosphine by farmers in this part of Africa because they are readily available and cheap, and their use is not centrally controlled (see paper by Brice, J and Golob, P, presented at this conference), the availability of the gas re-emphasises the need for training of extension workers and farmers.

Conclusion

Weight losses at farm level were not known before this survey. By using the rapid method of estimation, it was possible to calculate and analyse these losses over the period of storage. One of the most important observations reported here, is that weight losses are not as high as was previously supposed. The bruchid infestations appear to be much slower and weaker than experimental work infers. More experimental work is needed to understand this reduction of the potential population growth of the bruchids.

However, damage levels are high and economically significant. In a previous technical and socio-economic survey on post-harvest constraints and opportunities in cereal and legume production systems in northern Ghana (John Brice, unpublished data), it was reported that "farmers viewed pest control as an important area in the storage of grains throughout northern Ghana". Damage, mainly caused by the emergence holes of the adult bruchids, probably reduces seed germination and affects the appearance of the grain.

Because cowpeas sold by farmers are damaged, they command lower prices. Because of the risk of low prices, farmers cannot safely store their harvest until the prices are high for good quality commodities, and cowpea cannot be used as cash crop as much as it could. This is the case in Northern Region. In Upper East Region, farmers do not store large quantities of cowpea. The lack of certainty about the prices that they could obtain at the end of the storage period adds to production constraints. Previous studies have shown that cowpea sold on markets is usually of poor quality, with high levels of damage from bruchids. As this study has shown that only a small proportion of this damage takes place at the farm level, it is reasonable to postulate that damage might occur at the traders and wholesalers level, when large quantities of the commodity are stored. The next phase of this study will concentrate on this level.

This survey also reported the use of some traditional methods of protection, some of which are widespread. Their effectiveness needs to be ascertained. Alternative methods of protection have been developed, as part of this project, and should reinforce the protection offered to farmers, leading to even lower losses, and acceptable levels of damage.

Acknowledgements

The authors gratefully acknowledge the help of Dr Caroline Moss and the support of Dr Stephanie Gallat, Programme Country Manager (APPROMS), Accra.

This paper is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. R6503 Crop Post Harvest Research Programme.

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Table 1: Insect damage and weight losses of cowpea in northern Ghana (96-97).

	Region	Transformed data		Significance	Reverse transformed
		Average	SEM		
% Damage	Northern	0.608	± 0.035		32.6%
	Upper East	0.249	± 0.019	$p < 0.001$	6.1%
% Weight loss	Northern	0.219	± 0.013		4.7%
	Upper East	0.103	± 0.017	$p < 0.001$	1.1%

Table 2: Methods of treatment used on stored cowpea, ranked according to the percentage damage suffered:

Treatment	Region	Mean % damage	Transformed mean ± SEM	Number of farmers
Cypermethrin / sun dried		66.2	0.851	1
Phosphine / Cypermethrin		60.1	0.803	
Cypermethrin		45.3	0.685 ± 0.059	8
Sumicombi (Fenitrothion + Fenvalerate)		44.5	0.679 ± 0.126	4
sun dried	NR	40.5	0.646	
not treated	NR	36.2	0.608 ± 0.087	9
Cypermethrin / Sumicombi	NR	36.0	0.607 ± 0.003	2
Napthalene	NR	23.4	0.486 ± 0.053	2
Phosphine	NR	17.4	0.419 ± 0.032	5
Mix with ash, no heat: heated over fire later	UER	7.8	0.280	
Mix with ash	UER	7.4	0.272 ± 0.200	2
Heat over fire and mix ash	UER	6.2	0.248 ± 0.019	31
Heat over fire and mix ash and orange peel	UER	3.5	0.187	

Figure 1 Damage in cowpea samples during the second season (97-98) (mean ± SE)

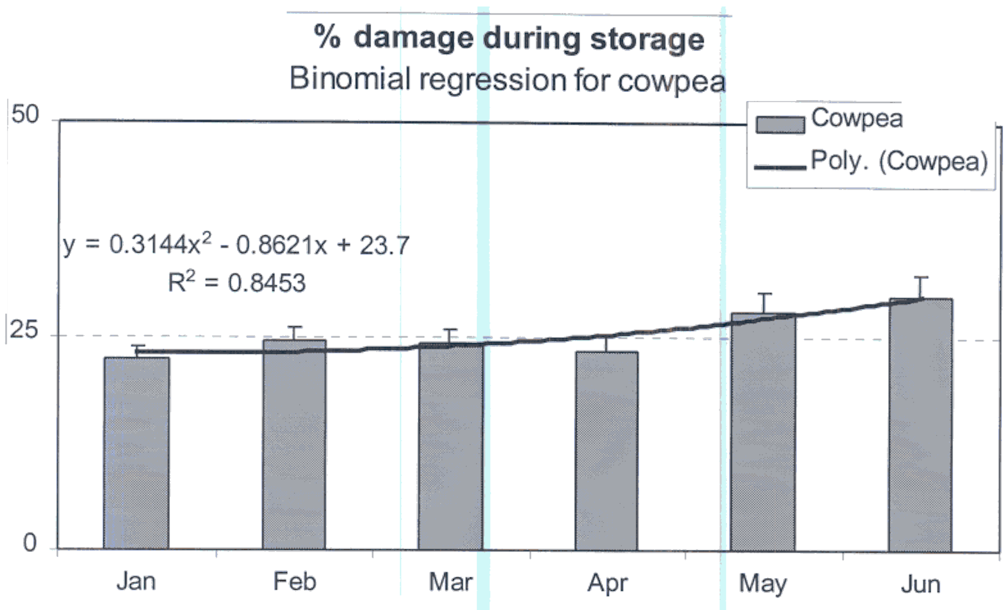

Figure Monthly removal of cowpea during the 1996-97 storage season expresses as the number of standard bowls (1 bowl = 4.5 kg).
Graph differentaites between removals for sale and removals for all other purposes

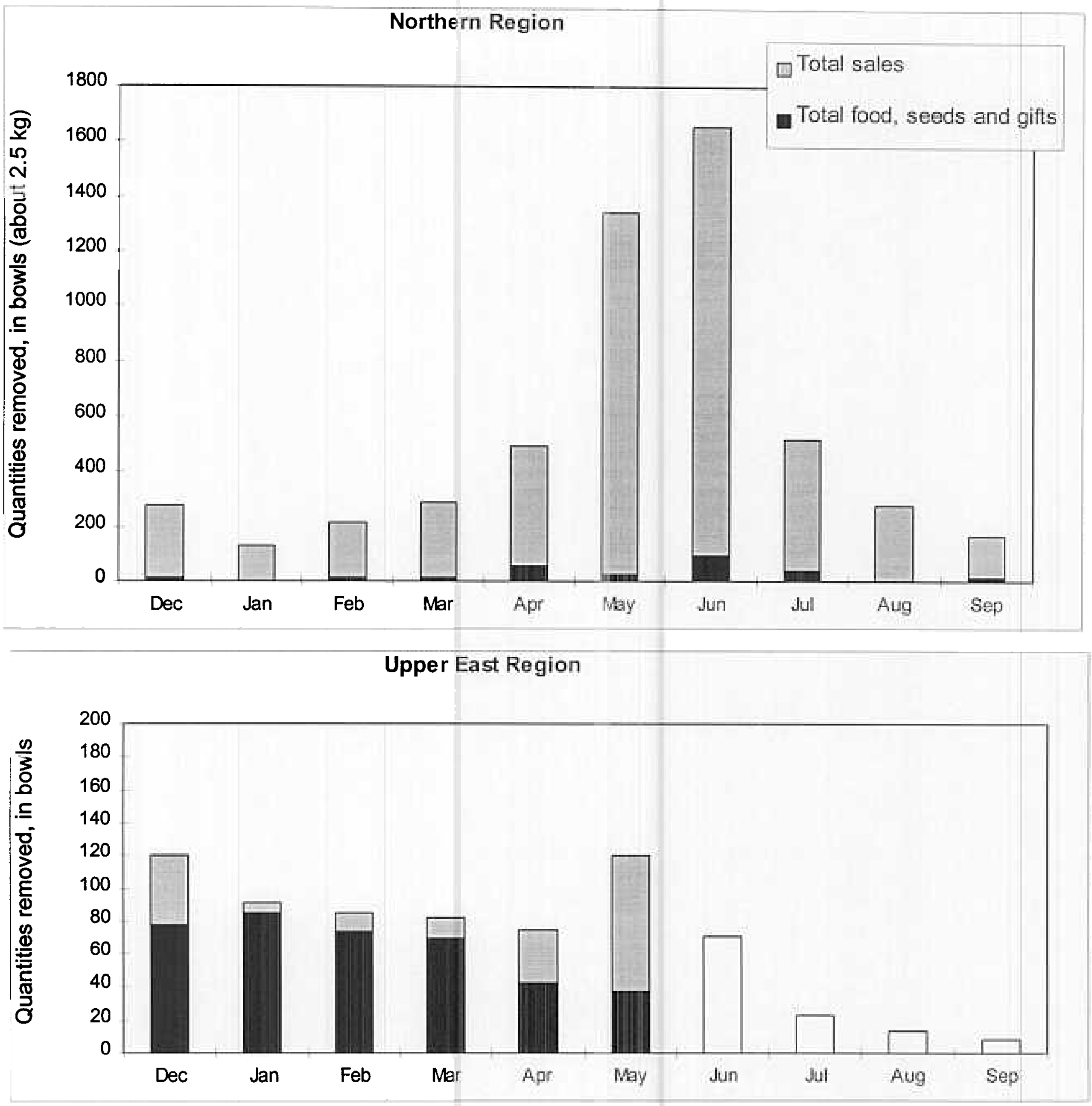

Figure 3 Average local market price of cowpea throughout the 1996-97 storage season.

Vertical bars represent the average number of bowls of cowpea sold per farmer.