R6501, R6502, R6503
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NRI
Natural Resources Institute

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Post-harvest constraints and opportunities in cereal and legume production systems in northern Ghana.

Ghana, 3 July to 5 August, 1996

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Projects:

A0493 (R6501),	The use of plant materials for protecting farm-stored grain against insect infestation.
A0494 (R6502),	Mud based silos: farm stores for cereals.
A0495 (R6503),	Improvement in the storage and marketing of grain legumes.

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GLOSSARY

CPHP	Crop Post Harvest Programme
CSIR	Council for Scientific and Industrial Research
FLS	Front Line Staff (within the MoFA)
LGB	Larger Grain Borer (*Prostephanus truncatus* Horn)
MoFA	Ministry of Food and Agriculture
PHO	Post Harvest Officer (within the MoFA)
PRA	Participatory Rural Appraisal
SARI	Savannah Agricultural Research Institute (within the CSIR)
SSI	Semi Structured Interviewing techniques
TAAP	Tamale Archdiocese Agricultural Project
NGO	Non Government Organisation
NR	Northern Region
UER	Upper East Region
UWR	Upper West Region
UDS	University of Development Studies (Tamale)

SUMMARY

1. A technical and socio-economic survey was carried out throughout the three northern regions of Ghana (Northern, Upper East and Upper West Regions) in July/August, 1996. The survey, using PRA methods, addressed issues concerning three, three-year long Crop Post Harvest Programme (CPHP) funded projects recently implemented by NRI in these regions (the projects commenced in April 1996). The three projects being: "The use of plant materials for protecting farm stored grain against insect infestation" (A0493); "Mud silos for the storage of cereals" (A0494), and; "Improvement in the storage and marketing quality of grain legumes" (A0495).

2. The survey used Participatory Rural Appraisal (PRA) techniques over a four week period to examine post-harvest practices, constraints and opportunities (for cereals and legumes) within the three northern-most regions in Ghana. Two teams, each with at least one scientist and one socio-economist (familiar with the technical content of the projects and PRA techniques respectively) were established. Having developed and tested the general methodology during visits to a number of villages around the Tamale area, the teams separated: the first team covered the eastern side of the northern region and then the upper east region, whilst the second team covered the western side of the northern region and upper west region. The two teams met to compare findings before and after visiting the upper regions. Each team visited approximately 11 villages, spending ideally one day in each village. Both groups and individuals were interviewed in each village: where possible separate groups of men and women were selected since views of practices and constraints were often found to vary with gender.

3. An initial discussion was held with the village elders/chief (with the rest of the village present) to collect information on general practices, problems, etc. During these discussions, data was collected, where possible, on the length of storage practised by individual farmers - this data was then used to select groups of farmers for further in-depth discussions. Information was collected from each of these groups on specific aspects concerning each of the three projects. Where possible, individuals not included in these discussions were taken aside by another member of the team to act as potential case studies (used in this report to either support or contradict specific points raised during the group discussions).

4. Severe constraints exist to the quantity of produce that can be grown: primarily due to falling levels of soil fertility (hampered by the high cost and poor availability of fertilisers); and the general scarcity of affordable cultivation equipment (animal and tractor drawn equipment), coupled with the high cost of labour. Quantities of commodities placed in storage are, therefore, generally lower than would be desired by farmers. Recommendations are made for the implementation of a parallel project to examine the possibilities of alleviating production problems, so allowing farmers to produce and, therefore, store larger quantities.

5. A wide variety of protection methods against insect attack, for grains and legumes, was encountered throughout the three regions. A total of 32 methods were identified: eight using inert materials (such as sand, ash, etc.); 19 using plant materials; and five using synthetic materials. Farmers perceptions of the effectiveness of different methods were found to vary considerably, making it difficult to assess which methods are more effective than others. Actual methods used were strongly influenced by tribal customs (as was the case with storage structures and the types of legumes grown), often resulting in neighbouring tribal

groups using totally different methods, usually with mixed results. A very real need was demonstrated for the testing of the effectiveness of specific methodologies, and recommendations are made to this effect (types of materials to be examined) for the forthcoming project activities.

6. Many types of storage structure were also found throughout the three regions. Of the 17 broad types of structure identified (including five basic types of mud structure), five key designs (including two types of mud structure) were systematically compared. The Mamprusi design of mud structure (that which is currently being recommended by the MoFA) was viewed by farmers as being by far the most effective for storage purposes. However, potential constraints exist to its further adoption: principally the cost and difficulty of construction; and its difficulty to use. Further extension by the MoFA will help to reduce the first two points through increasing the number of people capable of building the structure and educating farmers on the long-term benefits to be gained from the use of the silo. Recommendations are made for project activities: principally, it is essential to confirm whether mud silos of, or similar to, the Mamprusi design, is the most suitable store design for further extension (examining potential moisture and temperature problems within the stores with regard to its storage characteristics) and whether the design needs to be modified in any way; secondly, to examine methods of reducing termite attack (common to all types of structure), and thirdly; to assess the effectiveness/longevity of various types of mud mix.

7. Legumes were found to be widely grown throughout the three regions. Whilst improved, higher yielding varieties are available in most of the areas, poor resistance to disease and insect attack, both pre- and post-harvest, means that their usage is limited. Several local varieties have been identified and project recommendations have been made to assess their resistance to insect damage. Whilst insect damage in storage is undoubtedly a problem, other constraints, mainly financial, were identified as preventing long term storage. This had the effect of reducing the apparent pest control problems in some areas. However, if financial constraints can be reduced in the future, the quantities in, and the duration of, storage will be dramatically increased. Insect problems with the storage of legumes will then become severe if the problem is not addressed.

Chapter 1
INTRODUCTION AND TERMS OF REFERENCE

The survey addressed the technical and socio-economic needs of three research projects:

> The use of plant materials for protecting farm stored grain against insect infestation (A0493);
>
> Mud silos for the storage of cereals (A0494);
>
> Improvement in the storage and marketing quality of grain legumes (A0495).

These study areas formed components in a combined study undertaken by two teams working in three regions in northern Ghana (see Chapter 2: Methodology, for more details).

Each of the three projects is being funded under the Crop Post Harvest Programme (CPHP) of the ODA's Renewable Natural Resources Research Strategy (RNRRS) 1995 - 2005. The first two projects (A0493 and A0494) are being implemented in pursuit of Purpose 1 in the CPHP: "On-farm grain storage, marketing and credit systems improved", the target production systems for these projects being "semi-arid and hillside" systems. The third project (A0495) is being implemented in pursuit of Purpose 6 in the CPHP: "Qualitative and quantitative losses in storage reduced", targeting "high potential" production systems.

Ghanaian government approval was given for the projects earlier this year, and this techno socio-economic survey represents the first stage of implementation. All three projects are being implemented in collaboration with the Ministry of Food and Agriculture (MoFA), along with other institutions such as indigenous NGO's (e.g. Tamale Archdiocese Agricultural Project (TAAP) in Northern Region), and government research organisations such as the Savannah Agricultural Research Institute (SARI).

The emphasis given to certain aspects within the combined study was directed by the three project memoranda which, in turn, was developed from earlier work conducted on similar topics in Ghana. These earlier works principally include Golob *et al*, 1996, concerning the storage and marketing of grain crops. In addition to this work, the design and objectives of the study tōok on board the findings of Cobbinah (1996) regarding the application of plant materials as protectants to cereals and pulses stored on-farm; the analysis and conclusions of Gudrups *et al* (1995) on the subject of constraints to on-farm storage of pulses in Ghana; the findings of Nyangteng (1972) on storage structures; the findings of Brice and Ayuba (1996) on the types of storage structures found throughout the three northern regions; and the work of Golob (1993) on the misuses of aluminium phosphide tablets.

OBJECTIVES

Post Harvest Pest Control

Plant protectants have been used traditionally for pest control in Ghana for many years (Cobbinah, 1996). However, until recently, there had been little detailed investigation regarding their use. Studies by Niber *et al.* (1992, 1994) and Cobbinah (1996) have identified a number of indigenous plants species used to protect stored commodities against insect damage. Laboratory trials have been undertaken on a small number of these plant protectants to investigate their efficacy against common storage pests (Tuani *et al.*, 1994, cited in Cobbinah, 1996, Niber *et al.*, 1992, 1994). Insecticidal activity has been detected in extracts of *Ricinus communis* L (caster oil), *Solanum nigram* L (black nightshade), *Cissampelos owariensis* Beauv. ex DC, *Erythrophleum suaveolens* (Guill & Perr.) Brenam (Niber *et al.*, 1992) and *Azadirachta indica* Juss. (Neem) (Niber, 1994) against *Prostephanus truncatus* Horn, *Sitophilus oryzae* L, and *Acanthoscelides obtectus* (Say).

Previous studies have concentrated on the use of plant protectants in southern and central regions of Ghana. Plant materials are utilised as storage proctectants in the three northern regions (Golob, unpublished data) but until now, have received little attention.

Both Golob *et al.* (1996) and Gudrups *et al.* (1995) report the use of traditional and non traditional methods of post harvest pest control. Inert materials such as ash are used, especially for legumes, in northern Ghana. Golob *et al.* (1996) noted that several types of plant materials and extracts were used to protect grains, especially in the UER. Other methods include the use of chilli pepper, residue from shea nut butter manufacture and smoking of the commodity over household fires. Cobbinah (1996) carried out a detailed survey into the methods of protecting stored cereals in the Ashanti region of Ghana and found a total of 27 plant species as having protective qualities against storage pests of cereals. The use of non-traditional, synthetic chemicals, such as Actellic and phosphine were mentioned by all three of the references.

Prostephanus truncatus (Horn), or the Larger Grain Borer, (Coleoptera: Bostrichidae) is a serious storage pest of maize and dried cassava roots. Although indigenous to Central America, it was accidentally introduced into Tanzania during the late 1970's from where it has spread into Southern Kenya, Burundi and recently Malawi (GASGA, 1993). It was found in West Africa in 1984, presumably from a second introduction, from where it has spread to Benin, Ghana, Guinea Conakry, Burkina Faso and Nigeria. The incidence of *P. truncatus* is at present limited to the eastern side of Ghana but it is likely to spread into all maize and cassava growing areas. The need for effective storage protection methods will therefore increase in Ghana as a result of this new pest.

Given the wide range of methods of storage protection available to the farmer, there is a clear need to establish the selection criteria for the implementation of successful, affordable methodologies. The objectives of the survey were therefore to identify the needs and preferences of farmers for using grain protectants, placing particular emphasis on botanical insecticides. The effectiveness of the different methods, along with the potential constraints (cost, availability of materials, etc.) to their use, will be determined. Samples of plant materials will be collected and identified.

Storage Structures

Many types of storage structure are used throughout the three northern regions of Ghana. These range from simple raised platforms, through woven structures (with and without a wooden framework), to well constructed mud structures. For each basic type of structure, there are often many variations in design resulting in a multitude of store types (Nyangteng, 1972, and Brice and Ayuba, 1996). One of the primary factors determining the type of structure to be used is tradition - each of the many tribal groups found in the three northern regions have their own types of structure, and there tends to be very little transference of ideas from one group to another.

Each design has its own strengths and weaknesses with regard to its effectiveness in protecting the commodity, and likely adoption in areas where it is not traditionally found. Problems specific to certain localities, such as termites in UER (Golob *et al*, 1996) and the lack of suitable building materials, especially in the more densely populated areas around Tamale (Gudrups *et al*, 1995), place additional strain on the performance of some of these traditional structures.

P. truncatus (LGB), being related to wood boring insects, is capable of feeding and breeding in the wood of several tropical tree species (Nang'ayo *et al.*, 1993). This has important implications regarding both the control of this pest, and the reduction in strength of the structure. The wooden structure of a store can act as a reservoir in the absence of maize and cause rapid infestation of the new harvest. It is feasible that certain storage structures (for example mud based structures) will provide a better barrier against infestations by LGB than others(for example, wooden framed structures). Unfortunately, there has been no work to date regarding the efficacy of storage structures against infestations of LGB.

As a result of the lack of building materials, and the poor performance of some of the store designs traditionally found in the Tamale area, the MoFA have attempted to introduce a design of mud structure not traditionally used in this area - the Mamprusi mud silo. Silos have been built in several villages close to Tamale, with a limited number of people being trained in the construction techniques. Uptake has, to date, been limited and so the MoFA are reinstating the introduction programme.

The objectives of this technical, socio-economic survey were to determine the storage problems faced by the farmer and, therefore, their needs in terms of storage facilities. The survey assessed the extent to which existing storage structures, including mud silos, meet these needs at present by examining the strengths and weaknesses of the different store designs. Particular attention was paid small mud silos, such as the Mamprusi design, comparing them where possible to those store types currently used. The effectiveness of the structure (protection against moisture, insects, termites, theft, etc.) and its potential constraints to the further adoption (cost and ease of construction, availability of materials, pest damage, etc.), was addressed.

Storage and Marketing of Legumes

Whilst legumes are grown throughout Ghana, the bulk of production takes place in the three northern regions (Northern, Upper West and Upper East Regions). The most important grain legumes are cowpea (*Vigna unguiculata* (L.) Walp.), bambara groundnut (*Vigna subterranea*

(L.) Verdc) and, more recently, soya bean (*Glycine max* L.). The Ghanaian government has been promoting soya bean as a result of its high protein content (approximately 38-41%) (Gudrups *et al*, 1995). Pigeon peas (*Cajanus cajan* (L.) Millsp.) are cultivated and marketed on a much smaller scale. Other grain legumes include the lima bean (*Phaseolus lunatus* L.), the geocarpa bean (*Kerstingiella geocarpa* Harms.), winged bean (*Psophocarpus tetragonolobus* L.) and the sword bean (*Canavalia gladiata* (Jacq.) DC) (Gudrups *et al*., 1995). Groundnuts (*Arachis hypogaea* L.) are grown extensively in the northern regions for consumption and sale either as kernels or processed (predominately as oil but also as groundnut paste and snack foods in local markets) (Golob *et al*., 1996).

Grain legumes have a high protein content (average 20-26%) and are of particular importance as a subsistence crop in tropical and semi-tropical countries where there is a shortage of animal protein (Kay, 1979). In addition to their value as a food stuff, their nitrogen-fixing ability helps increase soil fertility without the use of expensive nitrogenous fertilisers.

Cowpeas form a major part of the Ghanaian diet in northern regions. Farmers cultivate between 0.4 and 2 ha often intercropped with cereals (Golob *et al*., 1996). The harvest is used predominately for family consumption but any surplus is sold to provide funds for financial needs such as medical expenses, school fees, etc.

Storage losses as a result of insect damage have been identified in cowpea and bambara groundnut during previous visits to northern Ghana (Gudrups *et al*, 1995; Golob *et al*., 1996). The losses are caused by members of the Bruchidae family (Coleoptera) which infest mature seeds in the field and especially in stores. The feeding of adult bruchids is of no economic importance, it is the larval stages which consume the seed reducing the quantity and quality available for human consumption.

Storage losses of grain legumes are not well documented in Africa due partly to a lack of suitable verified methodologies for loss assessment (Gudrups *et al*, 1995). A survey undertaken by the Post Harvest Loss Prevention Project in Uganda in 1992 identified losses to cowpeas of 1.7 and 5.9% of harvested crop after three and six months respectively (cited in Gudrups *et al*, 1995). A mean weight loss of 3.7% was recorded in bambara groundnut as a result of insect damage after five months storage under local Ghanaian conditions (Amuti and Larbi, 1981). Golob *et al*., (1996) determined average storage losses in the magnitude of 50% rising to 100% by weight of cowpeas after six months storage. Storage losses in bambara were also found to exceed 50% but the seeds were not usually damaged as quickly or to the same extent as cowpea.

Traders and wholesalers are responsible for much of the storage of grain legumes (Gudrups *et al*, 1995). Traders purchase produce immediately after harvest when prices are low and store for six to seven months until the lean period in May/June (Golob *et al*., 1996). Produce is stored in jute sacks in store rooms located either in or close to the market. Insect damage was greatest in this group due largely to the extended storage period and lack of protection and adequate storage facilities (Gudrups *et al*, 1995). Fifteen to 94 percent of cowpeas for sale in local markets in northern Ghana during May/July were observed to exhibit insect emergence holes (Golob *et al*., 1996). Damage to bambara groundnuts ranged from 14% to 100% of seeds containing insect holes during the same period.

Grain legumes, stored either at the farm or wholesale level, are subject to considerable losses as a result of insect damage. Evidence of this damage has been collected during previous surveys but the findings obtained at farm level are largely anecdotal. Further information is required regarding the socio-economic and physical factors, such as insect damage, which prevent farmers storing grain legumes for as long as they would wish.

The objectives of the legume component of this survey were therefore to: identify the methods of on-farm storage used for grain legumes (to complement the information obtained on trader storage by Golob *et al*); to confirm which varieties of legumes are grown and stored by farmers, together with their growing and storage characteristics; and to determine the typical storage life of legumes, together with the reasons for early sale.

TERMS OF REFERENCE

Although the specific terms of reference varied slightly between members of the teams (primarily in providing advice specific to their subject areas), the general TOR's were as follows:

a) To participate in the technical and socio-economic study throughout the three northern regions of Ghana. Two teams will visit a number of villages, collecting detailed information regarding three CPHP projects - Plant Materials (as protectants against insect damage during storage), Mud Silos, and Legumes (storage and marketing).

b) [In the case of J Brice and C Moss] To identify individuals from the MoFA, SARI and NGO's during the week prior to the study who would form the two teams. To visit the three regions in question and draw-up an itinerary with the local Post Harvest Officers, including the identification of the villages to be visited.

c) To develop the study methodology during the first week of the study. To ensure that the teams cover key areas within the three regions.

d) To provide specific advice in respect to their subject area.

e) To produce a final report on the study by the end of September, 1996.

Chapter 2
METHODOLOGY

INTRODUCTION

Prior to the field work, a list of key areas of interest was produced based on the project activities listed in the three Project Memoranda. Team members then split into two groups and 'fine-tuned' the methodology during the first two days of the PRA (15 and 16 July). Once the teams were satisfied with the questions and methodology, they separated on the third day to cover the western and eastern sides of the Northern Region (17 to 21 July). Results were compared on the 22 July, after which the teams separated again to cover the UE and UW Regions from the 23 to the 29 July. Data were then collated, and villages around Tamale visited. Thus, the field work lasted approximately 2½ weeks, with the last village being visited on 1 August.

PRA TEAM COMPOSITION

Two teams were used to cover the three Regions (Teams A and B, Appendix 1). Each team consisted of at least three full time members (a member of NRI actively involved with one or more of the projects, a socio-economist, and a PHO and/or a member of a local NGO who was acquainted with the locality). The teams were joined at each village by the local Front Line Staff (of the MoFA) who had intimate knowledge of the village in question.

VILLAGE SELECTION

Using advice from the Regional PHO's and TAAP (in the case of the Northern Region), key geographical areas (using sampling criteria discussed below) were identified within the three regions. Specific villages were then selected (usually by conferring with the MoFA District Agricultural Extension Officers) within these areas. A selection of criteria were used to arrive at the number and location of the villages visited during the study. Three sets of criteria can be identified: sampling in pursuit of representativeness across the three regions; project specific considerations and; constraints.

a) **Sampling and representativeness:** This set of criteria was concerned with ensuring that the conclusions derived from the village level work could be generalised to inform regional and pan-regional interventions. The initial "sampling frame" was delineated so as to exclude the southern part of the NR (where root crops, especially yams, prevail and little grain or legumes are grown), thus only true savannah areas were sampled[1]. In these areas, cereals form the major staple foods and grain legumes are widely grown. Within this "frame", villages were stratified according to major ethnic groups. An explicit objective of selection was to ensure that all main ethnic groups were represented. This is justified on the grounds that tribe is a good predictor of type of structure(s) used to store grain (Brice and Ayuba, 1996). A final criterion was population density to ensure that key areas were sufficiently well represented in the survey. As noted

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[1] In practical terms, this meant excluding all areas to the south of Yendi in the east, and to the south of Bole in the west.

in Runge - Metzger and Diehl (1993), "among climate, soils and demography, certainly the latter exhibits the highest variability across the region [Northern Ghana]". Population density has impacts on important agro-economic factors such as deforestation, land degradation and establishment of markets. All of which can influence storage and marketing behaviour.

b) **Project-specific considerations:** Subject to the above issues, it was felt necessary to select a certain number of villages in which it was known that plant materials were widely used. This was to ensure that a reasonable amount of material was collected for identification. (In the event, plant materials were found in several villages which had not been purposively selected). In addition, some villages in UER were selected on the grounds that mud silos there were known to have been damaged by termites. Finally, the main criterion for selection of three of the five villages visited near Tamale was that the MoFA were attempting to introduce mud silos in these villages.

c) **Constraints:** Time, transport and personnel constraints placed clear limits on the number of villages visited and the time spent in each village. They also defined the methodological options. In retrospect, more ground could have been covered and more depth achieved if the study had been planned differently. One limitation of the design, especially with regards to the marketing of commodities, was that, whilst population density was considered, distance to markets and transportation conditions were not. However, these factors had been taken into account by Golob *et al* (1996) in their detailed study of the marketing of grain crops.

Experiences with the planning and execution of the study can perhaps serve as lessons for future studies.

Despite the limitations imposed by the constraints (for example the time spent at each village), and the project-specific considerations (for example, selection of villages with Mamprusi silos around the Tamale area and villages using plant materials), the selection methodology is analogous to Senaratnes' "windows into regions" as described by Chambers (1983). As such, the villages selected offer a snapshot of conditions which can plausibly be expected to exist elsewhere within particular sample strata (tribal group, geographical location and population density). This in turn makes it legitimate to argue that the conclusions generated by the study will have a more general applicability within the three regions visited. The villages, District and Tribal groups are listed in Table 1 and illustrated in Figure 1.

Table 1 Villages visited during the survey

Code	Village	District	Tribal Group	Date visited	Duration (days)
Northern Region					
1	Zakari Yili	Tamale	Dagomba and Fulani	16/07/96	¾
2	Tunayile	Tolon Gumbungu	Dagomba	01/08/96	1
3	Datoyili	Tamale	Dagomba	16/07/96	½
4	Duuyin	Tamale	Dagbani	01/08/96	½
5	Jerigu	Tamale	Dagomba	01/08/96	½
6	Baghani	Yendi	Dagomba	18/07/96	1
7	Gbenja	Chereponi Saboba	Kokomba	19/07/96	1
8	Bumboazio	East Mamprusi	Mamprusi, Gonja, Talensi, Fulani	20/07/96	¾
9	Achubumyor	Damongo	Gonja, Dagomba, Frafra, Dagati	21/07/96	½
10	Yipala	Damongo	Dagatis (with a few Sisala and Mamprusis	18/07/96	1½
11	Mandari	Bole	Safalba, Gonja, Dagati, Jula	19/07/96	1
12	Naafaa, near Tuna	Bole	Brefor	20/07/96	1
Upper West Region					
13	Bulenga	Wa	Chakale (with some Dagati and Waala)	24/07/96	1
14	Nabolo	Tumu	Sisali (with a few Falani)	25/07/96	1
15	Jumo near Funsi	Tumu	Sisali	26/07/96	½
16	Silbelle	Tumu	Sisali	27/07/96	½
17	Brutu	Lawra	Dagati	28/07/96	¾
18	Bamahau	Wa	Walaa (66%), Dagati (33%)	29/07/96	½
Upper East Region					
19	Piaga-Chiok	Bulsa	Bulsa	25/07/96	1
20	Nangalikinia	Kasena/Nanken???	Kassena and Nankan	26/07/96	¾
21	Bongo-Soe	Bongo	Bongo, Saba	24/07/96	1
22	Booya	Bawku West	Kusasi	27/07/96	1
23	Pialoka Pusiga	Bawku East	Kusasi	28/07/96	¾

Figure 1 Location of the villages visited during the survey

TOOLS OF THE STUDY

Details of the 'Survey Design and Methodology' and the 'Checklists and Tools' used during the survey are listed in Appendices 1 and 2 respectively. The approach is summarised below.

(a) Village Introduction, Case Studies and Group Work

Village Introduction Upon arrival in each village, discussions were held with a gathering of villagers. The objective of this initial discussion, generally lasting between 1 and 2 hours, was to gain a general overview of the farming, storage and marketing systems (including gender divisions) practised in the village. This served as a platform for subsequent discussions in gender or storage groups and individual case studies.

Case Studies Particular informants were purposively selected and in-depth discussions were held on important topics. Informants were selected using a variety of criteria, including gender, age and length of time for which the crops were stored. Case studies were useful as they allowed rapid gathering of detailed personal information which often served to illustrate or magnify less detailed group work findings.

Group Work In the design of the study, two important criteria for group selection were used: storage duration; and gender. Wherever possible, a random sample was taken of villagers attending the initial village introduction. Those individuals selected were then interviewed separately to ascertain the length of time that they stored cereals and legumes in a "normal year". Individuals falling into the same (pre-determined) category were then grouped together, and interviewed in groups using the PRA techniques described below. In addition to this, where possible a group of women was interviewed separately in each village. It was found useful to do this as women often had different production, storage and marketing roles than men. In several villages, time or other logistical considerations meant that it was not possible to form all these groups. In such cases, discussions and ranking/scoring exercises were normally done separately with a group of men and a group of women.

(b) PRA Techniques

In most cases, each team spent a day per village, administering a combination of the following: semi-structured interviewing based on a pre-determined checklist; direct observation; preference ranking, and; direct matrix scoring (see Appendix 2 for definitions and actual questions asked). As already noted, time or other logistical considerations meant that in some villages it was either not possible or necessary to do a full days survey. In such villages, PRA teams tended to focus on key issues. For example, in villages 2, 4 and 5, where the MoFA had attempted to introduce mud silos, teams concentrated on storage structures, placing less emphasis on storage protection and grain legumes. In other words, within the framework of the checklists, the teams focused on what appeared to be important within a particular village. This inevitably involved dropping altogether some questions and areas, attempting to generate "hard data" only where this was feasible (so as to avoid spurious accuracy) and expanding aspects of the enquiry where the situation within a particular village required this.

Particular care was taken both at the beginning of the survey (when establishing the PRA methodology), and subsequently when working in the villages, with regard to the wording of questions and the analysis of responses. It was found that responses to questions concerning specific subjects were often influenced by other factors. For example, whilst developing the methodology, it became apparent that the scoring of stores against their 'effectiveness to protect against theft' comprised a combination of the security of the store structure itself AND the location of the store. In a few cases, although the store itself provided little protection, the fact that it was placed in the living quarters resulted in a high score for security against theft. Great care was therefore taken, usually by careful wording of the questions and in-depth follow-up questions, to ensure that it was clear what information was being obtained.

(c) Other Activities: Samples and Secondary Data

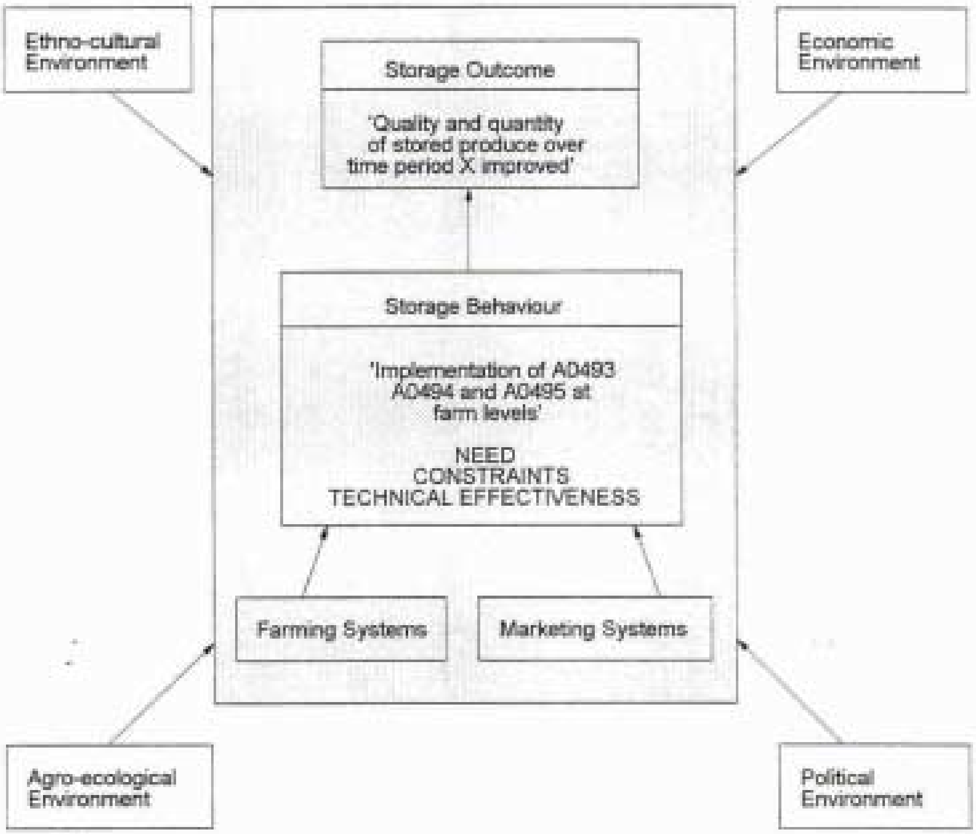
Samples In addition to the PRA work, both teams collected two types of samples, plant materials used for storage protection, and cowpeas and bambara groundnuts. Certain plant materials were selected for subsequent analysis in the laboratory to ascertain insecticidal qualities, and the cowpeas and bambara will be examined to establish their resistance/susceptibility to insect infestation.

Secondary Data Information was collected from MoFA and SARI on previous post harvest trials and surveys conducted within the three northern regions. This information will be drawn upon where appropriate in this report.

PRIORITIES AND LINKAGES

The three projects need to be understood in the context of pre and post-harvest systems and the determinants of these systems. Figure 2 presents a simplified picture of some of the key linkages.

Figure 2 Linkages between the projects, pre and post harvest systems and "environmental" factors.



Notes:

Ethno-cultural environment:
- Tribe
- Gender relations
- Generational factors
- Social events (weddings, funerals)

Agro-ecological environment:
- Rainfall
- Temperature
- Soils
- Topography
- Indigenous and imported flora and fauna (including trees and pests)

Economic environment:
- Input prices
- Output prices

- Factor scarcity
- Access to markets
- Household expenditures (school fees, hospital fees, clothes, condiments etc.)

Political Environment
- MoFA policy
- Legislation

Interpretation:

The model consists of five basic elements: Farming systems; Marketing Systems; Storage Behaviour; Storage Outcome; and, Environmental Factors. Of the first four elements, the Farming and Marketing Systems can be said to be direct determinants of Storage Behaviour, whilst the storage behaviour is a direct determinant of Storage Outcome. The fifth element, the Environmental factors, consist of four factors: ethno-cultural; agro-ecological; economic and; political. These four environmental factors can affect the other four elements in a multitude of ways.

The model (Figure 2) gives a good basis for understanding the technical and socio-economic issues involved in the mud silos, plant protection and legumes projects. The "Implementation of A0493, A0494 and A0495 at farm level" box feeds directly into the "Quality and quantity of stored produce over time period X improved" box. This outcome can be said to be the objective of the three projects. Focusing on the implementation box, the diagram is indicating that, in order to achieve this objective, the projects must satisfy three sets of conditions. First, they must be addressing a real need, as expressed by farmers in the survey and as established through other sources. Second, implementation must not be prevented due to key constraints such as cost, availability of materials and skills. Finally, they must result in interventions that are technically effective in addressing farmers storage needs.

The remainder of this report is organised around the three issues of need, constraints and technical effectiveness. Fieldwork results will be used to determine the magnitude of each of these, and, where possible and appropriate, to estimate the strength of the various linkages between project implementation, environmental factors, farming systems and marketing systems. By investigating the strength of the various linkages, it should be possible to enhance project implementation.

Chapter 3
OVERALL VIEW OF FARMERS' AGRICULTURAL NEEDS AND CONSTRAINTS

In each village, the teams sought to obtain a perspective of the priority that farmers place on storage problems in relation to other agriculturally related problems. By asking farmers to rank the importance of these problems it became possible to place the storage issues in context and then to begin to explore linkages between storage and other problems. Table 2 presents a summary of the results of this exercise.

Table 2 Summary of agricultural constraints expressed by farmers

Constraint	Type	Number of Villages Mentioned	Regions where not mentioned[2]	Mean Ranking
Access to labour saving technology for land preparation[3]	P	13		1.69
Storage pests	S	13		4.15
Cost and/or availability of fertiliser	P	11		3.00
Uprooting of seeds by birds and rodents	P	11	UER	3.45
Marketing problems[4]	M	10	UER	3.20
Weeds[5]	P	8		3.13
Poor Rainfall[6]	P	7		3.57
Livestock diseases	P	4		3.50
General financial constraints		4	UER	4.75
Land fertility	P	3	UWR	2.33
Seed availability and cost	P/S	3	UWR	2.33
Food availability at planting time		2	UER,UWR	1.00
Monkeys/rodents eating crops in the field	P	3	UER,UWR	2.33

Key: P = Production (Farming System) Constraint
S = Storage System Constraint
M = Marketing System Constraint

Taking into account (a) mean rank, (b) frequency with which a factor was mentioned and (c) geographical spread of responses, access to labour saving technology for land

[2] This column gives only a very crude indication of regional differences in priorities.
[3] Usually either tractors or bullocks
[4] This includes: early sale; low prices; low bargaining power in relation to middlemen, and; transport problems.
[5] Usually Striga.
[6] This was mentioned in only one village in the NR where it was ranked 6th. It was ranked highest in the UWR.

preparation was the most important single agricultural problem. This was felt particularly acutely in the areas affected by the recent tribal conflicts (east of Tamale) where ploughs and draught animals had been destroyed and farmers could not afford to re-equip themselves. Storage pests were mentioned as a problem in the same number of villages as labour saving technology, but consistently received a lower rank: generally storage problems were ranked 4th or 5th when mentioned, whereas labour saving technology was consistently ranked 1st or 2nd. Indeed, of all the other problems mentioned, only general financial constraints - with a score of 4.75 - received a lower mean rank than storage problems. Cost and/or availability of fertiliser, uprooting of seeds by birds and rodents, and marketing problems were each mentioned in more than half the villages, and each received a mean rank of between 3 and 4. Of these three factors, fertiliser scores had the lowest standard deviation, followed by seed uprooting and then marketing difficulties. Seed uprooting and marketing problems were not mentioned in any of the UER villages visited.

The table shows that, in the villages visited, production problems predominate. Of 13 problems mentioned: nine are clearly production related; two of the problems (food at planting time, and financial constraints) defy easy classification; the final two being storage and marketing related respectively.

CONCLUSIONS

Difficulties created by storage pests were mentioned frequently by farmers in all three regions. However, storage problems would appear not to be critical constraints in the eyes of farmers, certainly when compared to other issues such as lack of affordable labour saving technology and the high cost of fertiliser.

Notwithstanding this, the importance of storage problems seems set to change as *P. truncatus* (Larger Grain Borer, LGB) spreads north and west from Volta Region, where it has become a major pest. LGB is a serious storage pest of maize and dried cassava roots. In Tanzania losses as high as 34% have been observed in maize cobs after 3-6 months farm storage (Hodges *et al.*, 1983) and losses of 70% have been recorded in cassava after only four months storage (Hodges *et al.*, 1985). When compared with the damage caused by the more common storage pests such as *Sitophilus oryzae*, *S. zeamais* and *Sitotroga cerealella* under similar conditions, *P. truncatus* is considerably more destructive. Maize losses due to these other pests were only 2-6%, 3.5% and 2-3% after an entire storage season in Zambia, Kenya and Malawi respectively (Tyler and Boxall, 1984).

Even with LGB, however, the fact remains that issues other than those concerned with storage structures or storage protection methods will continue to impinge upon storage outcomes. At present, one of the principal reasons why storage periods are limited is the low levels of production and therefore the small quantities placed in storage. In addition to this, farmers are often forced to sell crops to release funds in order to pay off debts accrued over the growing season and/or to meet unavoidable expenses such as school fees.

With or without LGB, these linkages have important implications for the impact of the projects on the goal of increasing the quality and quantity of on-farm stored produce.

The key question that has to be answered is: in the context of such production and financial constraints, what will be the impact of improved storage structures and practices? It is the opinion of the authors that this should be explicitly ascertained as part of present project activities, and relevant action taken in the next phase of the three projects.

RECOMMENDATIONS:

It is **recommended** that the technical outputs of projects A0493, A0494 and A0495 be field tested in different financial and production environments.

The objective of such testing will be to ascertain the strength of linkages between improved storage protection, storage structures and varieties (in the case of bambara and cowpeas) on the one hand, and storage outcomes on the other. These linkages are best tested by comparing the performance of the technical outputs in different production and financial environments. For example, the impact of the technical output of A0494 (an improved storage structure) on the quantity and quality of stored produce could be compared in differing credit situations - one situation where there is restricted or zero production and post harvest credit, compared with a situation where farmer credit was readily available[7]. The research hypothesis would be that the impact of the improved structure on the quantity and quality of stored produce is strongly affected by the availability of production and/or post harvest credit.

[7] In this respect, it might be possible to make links with IFAD and Technoserve who have introduced credit schemes into areas in Northern Ghana.

Chapter 4
POST HARVEST PEST CONTROL

The objectives of the survey were to identify the needs and preferences of farmers for using grain protectants, placing particular emphasis on botanical insecticides. The effectiveness of the different methods, along with the potential constraints (cost, availability of materials, etc.) to their use, will be determined. Samples of plant materials will be collected and identified.

IDENTIFICATION OF STORAGE PROTECTION METHODS

Twenty villages throughout northern Ghana provided information on their methods for protecting stored produce (Table 3). A total of 32 methods of protection against insect attack were identified. These were divided into eight methods using inert materials, 19 methods using plant materials (using 17 plant species), and five using synthetic materials.

The storage of commodities was undertaken by both men and women in the majority of villages visited. Gender, however, determined the type of commodity which men and women were responsible for storing. Men were predominately in charge of storing the family food crops while women usually stored produce harvested from their own farms. However, variations in storage responsibilities were observed during the survey, for example, all the produce was stored by men in the village of Tunayili (NR near Tamale) and only by women in Naafaa (NR near Bole). Who stored the produce, however, had little effect on the type of method used to protect it from insect damage.

Seventeen out of the 20 villages used plant materials in some form to protect stored produce from insect losses. The use of plant protectants was slightly biased towards those villages situated in the Upper East Region (UER) and those in the north-east of the Northern Region (NR). While this may have been due to a number of factors (such as tribal groups, availability, etc.), variations in the wealth of farmers undoubtedly had an effect. Generally, farmers in the eastern side of the surveyed area, especially those in the UER, appeared to be poorer than those in the west.

Of the 17 types of plant material identified as having insecticidal properties (Table 4), many were common to several villages including: shea nut residue, chilli pepper, neem, lodel, kim-kim, kul-enka, mahogany bark and poni. Kim-kim was the most widely used plant protectant (6 villages) followed by chilli pepper (5 villages), lodel (4 villages), shea nut residue and neem seeds (3 villages each) and poni (2 villages). Specimens of 13 of these plant species were collected and have been sent to the Royal Botanic Gardens at Kew for identification (Appendix 3).

Thorough drying of sorghum and maize was found to be an important factor in several villages (for example, Achubumyor, NR) in accounting for the length for which these crops could be stored without spoilage. This raises the possibility that processing may be a more important factor in determining storage quantities and quality than type of structure or protectant.

Table 3 Protection Methods used throughout northern Ghana

Protection method	Village	Crop	Method of application
Inert:			
Wood ash	2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 & 23	All	Mixed with dried produce. The ratio of ash varied between 2:1 ash to produce in UWR and NR to a "fist sized" quantity of ash to a "washing-up bowl" of produce in UER. Villages 8, 19, 21, 22 & 23 roasted with ash then stored in ash.
Ash from Dawadawa	15	All	as above
Ash from cowdung	15	All	as above
Sand	10, 11, 12, 17	All	Mixed with dried produce.
Smoke	1, 6, 7, 8, 9, 10, 11, 16, 19, 20, 21, 22	Maize	Hung over fire.
Fire	14, 15, 21	All	Fire was lit inside store (mud silo).
Thermal disinfestation	12, 17, 19, 22	All	Dried in sun for 1-2 weeks. Village 22 also placed seed in a bottle in the sun for several hours.
Pre-wetting	1, 6, 7, 12, 22	Bambara groundnuts	Dry, re-wet or leave in rain before storage. Village 22 pre-wetted maize cobs.
Plant Materials:			
Shea nut residue	2, 6, 8, 1	Cowpea and bambara	Mixed with dried produce.
Pepper	2, 6, 12, 13, 15	as above	Dried and sprinkled on top of produce.
Shea nut & pepper	1, 6	as above	Mixed with dried produce.
Neem seed	2, 6, 7, 19		Ground to powder and mixed with produce.
Neem leaves	14, 17, 22		Dried leaves ground and mixed with produce. Village 14 used neem mixed with ash and also applied a neem solution to the inside of store walls. In village 17, leaves were layered with produce.
Mahogany bark	9	Maize, bambara or cowpea	Bark pounded into a powder and mixed with produce. Village 18 mixed bark with root from the soap tree (Kotokoli) before adding to produce.
Lodel, Dabokuka/Chia or Weldwa/Barrack	17, 20, 21, 22	Cowpeas, bambara, millet and sorghum	Leaves ground into a powder, mixed with produce or sprinkled at base of silo to prevent termite attack. Village 17 mixed dried pepper with lodel.

Kim-kim/ Bonti or Vagala/Dunkpoo	8, 9, 20, 21, 22, 23	Bambara groundnut (unshelled?)	Leaves boiled until water turns red (sometimes with leaves of Famatitabga) poured over bambara or immersed in water for 1-2 minutes.
Dumbliva	11	Maize and bambara	Seeds are ground to a powder and mixed with produce. Looked similar to kim-kim.
Dungvari	17	All cereals	no information. Possibly the same as kim-kim.
Kul-enka	20, 21	Cereals and pulses	Flowering head mixed with produce.
Famatitabga	8	Bambara groundnuts (unshelled?)	Leaves boiled with leaves of "Dunkpoo" until water turns red, bambara immersed in water for 1-2 minutes, dried.
Palga/Poni (root)	6, 13	Pulses and cereals ?	Roots ground into a powder and mixed with produce. Alternatively a solution is sprinkled on seed.
Lidikonja	7	Sorghum and millet	Leaves and flowers dried and layered with produce in silo.
Denkonja	7	Maize, cowpea and bambara	Seeds are spread in store (silo?) before produce. Sometimes layered with produce.
Kpasiuk	20	Millet, cowpea and bambara	Mature plants mixed with produce.
Dakpezungwari	22	Bambara groundnuts (unshelled?)	Leaves are boiled then removed, immerse bambara for 1-2 minutes, remove and dry.
Orange peel	21	Grain and bambara	Peel ground to a powder and mixed with grain.
Kola plant	20	Millet, cowpea and bambara	Plant cut up and spread on top of stored produce.
<u>Synthetic Materials:</u>			
Actellic (pirimiphos-methyl)	2, 6, 7, 8, 10, 13, 16, 18, 19, 21, 22	Maize	Mixed with produce. Village 16 mixed with ash.
DDT	11	Maize	Sprinkled over produce
Phosphine	6, 7, 8, 9, 10, 11, 13, 16, 17, 18, 21, 22	Maize	Tablets wrapped in polythene/rubber and 2-3 added to a sack of produce
Calcium carbide	9	?	no information.
Moth balls (Napthalene)	20, 21	Threshed grain and cowpeas	Moth balls mixed with grain.

Villages: 1 to 5: Tamale area; 6 to 8 eastern NR; 9 to 12 western NR; 13 to 18 UWR, 19 to 23 UER.

IDENTIFICATION OF STORAGE PROTECTION FACTORS AND SCORING OF PROTECTION METHODS

(i) Storage protection factors: Farmers were asked to consider the factors which they thought influenced their choice of a particular protective measure. A total of seven factors were described as being important to their choice of protection: cost, availability, ease of use, effectiveness, acceptability, versatility and toxicity.

(ii) Ranking: Farmers were then asked to rank the factors in order of importance. Cost was awarded the highest mean rank, closely followed by effectiveness, availability, toxicity, ease of use, acceptability, and versatility (Table 4).

Table 4 Ranking of Factors influencing the type of Storage Protection.

Factors	Mean Ranking[8]	Frequency[9]
Cost	1.8	11
Effectiveness	2.5	11
Availability	2.5	10
Toxicity	3	3
Ease of use	3.9	10
Acceptability	4.4	5
Versatility	5	6

The frequency with which a particular factor was mentioned does not necessarily relate to its ranked importance. For example, although "cost" was the most frequently mentioned factor and received the highest overall mean rank, "toxicity" had a mean rank of 3 but was only included in the matrices of three villages visited during the survey.

(iii) Scoring of methods of protection against factors: Matrices were constructed and a quantitative score of 0 to 10 was awarded for each of these factors against each method of protection (where 0 was useless and 10 was excellent). A mean score was calculated from the matrix data, and the results of this are presented in Table 5 (the numbers of villages that different pest control treatments were found are listed in Table 6). The standard deviation, number and median of the scores are provided in Appendix 3.

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8 Mean ranking applied by villagers.
9 Frequency relates to the number of villages in which this factor was raised.

Table 5 Mean Scores of Storage Protectants against Storage Factors

Factors	Inert materials			Plant materials												Synthetic materials			
	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plant[10]	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Mahogany	Orange Peel	Kola plant	Actellic	Phosphine	DDT	Calcium carbide
Cost	9.1	8.2	9.7	10.0	9.0	7.0	7.0	8.0	8.5	9.0	6.7	2.5	5.0	2.0	8.0	2.8	2.6	3.0	2.0
Availability	8.5	8.1	10.0	6.0	4.0	4.0	6.4	7.3	7.0	7.8	7.3	5.0	7.0	1.0	6.5	2.8	2.5	1.0	5.0
Ease of use	8.4	7.8	9.0	10.0	3.0	8.0	6.2	5.8	8.0	7.8	5.8	6.0	7.0	4.0	5.0	4.9	4.0	1.0	5.0
Effectiveness	6.0	6.4	4.0	10.0	3.0	8.0	6.3	5.8	6.0	4.8	9.0	7.7	4.0	6.0	7.0	7.8	8.6	2.0	5.0
Acceptability	4.4	3.0		10.0	4.0	7.0	6.6	4.5	5.0	1.5	7.7	8.3		5.0	8.5	7.9	9.6		
Versatility	4.5	3.9		9.0	7.0	6.0	5.4	5.0	6.0	4.0	7.7	9.0	10.0	6.0	6.5	9.1	7.0		8.0
Toxicity	7.0	10.0	9.5				6.7		8.0	7.0	7.5					1.5	1.0	0.0	

where 0 is useless, 10 is excellent

Table 6 Frequency that each type of Storage Protectant was scored against Storage Factors

Factors	Inert materials			Plant materials												Synthetic materials			
	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plant[10]	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Mahogany	Orange Peel	Kola plant	Actellic	Phosphine	DDT	Calcium carbide
Cost	11	9	3	1	1	1	6	4	2	4	3	2	1	1	1	9	8	1	1
Availability	11	10	2	1	1	1	5	4	1	4	3	3	1	1	2	9	8	1	1
Ease of use	11	9	3	1	1	1	5	4	2	4	4	3	1	1	2	8	7	1	1
Effectiveness	12	10	3	1	1	1	6	4	2	4	4	3	1	1	2	9	8	1	1
Acceptability	7	7	0	1	1	1	5	4	1	2	3	3	0	1	2	7	5	0	0
Versatility	8	8	0	1	1	1	5	4	1	3	3	3	1	1	2	7	6	0	1
Toxicity	3	1	2	0	0	0	3	0	2	2	2	0	0	0	0	2	3	1	0

[10] Combination of several plant protectants were scored together in one village only

TECHNICAL EFFECTIVENESS OF STORAGE PROTECTANTS

The effectiveness of a storage protectant was ranked as the (joint) second most important factor farmers considered when choosing a protection method (Table 4). The combination of shea nut residue and chilli pepper was identified as the most effective method of protection among those investigated. However, only one village used this treatment and, of the protection practices employed in more than one village, leaves of the lodel plant were found to be the most effective method of preventing insect damage. The chemical insecticides, Actellic and phosphine, were considered to be less effective than lodel leaves, but equal or greater than the remaining plant protectants investigated. DDT was, rather surprisingly, considered ineffective for protecting stored products. Further questioning determined that the farmers in this particular village mixed DDT with ash before adding it to the stored commodities. The matrix score had been awarded for the efficacy of DDT on its own, not in combination with ash. When asked to score its efficacy in combination with ash, the farmers awarded DDT a score of 10. A sample of DDT was not available for inspection; it was unclear if the term DDT was a generic name or that the chemical insecticide in question was actually DDT.

The inert materials, ash and smoke, were considered by most farmers interviewed to be effective storage protectants although the mean scores were slightly lower than those of Actellic, phosphine and several of the plant protectants (shea nut oil and chilli pepper, chilli pepper, lodel and kul-enka).

Many of the villages surveyed had some experience of using conventional insecticides which, if used correctly, are very effective at eradicating stored-product pests. The application of the insecticide Actellic appeared to follow the recommended guidelines, however, fumigation methods (using phosphine) were found to be highly dangerous. Phosphine was primarily used as a rodenticide. Tablets were either wrapped in cotton/polythene and left under or near the sacks of produce, or they were mixed with food and spread around the buildings. It was also used as an insecticide, between one and three tablets (often wrapped in either a cotton or polythene material) were placed in an unlined jute sack (100 kg capacity); in the case of two or three tablets, they are usually located at the base and in the middle of the bag. For security reasons, the bags were then kept in the household compound, in some cases even in the bedroom (for example, village 11). In some cases, it appeared that the phosphine, and instructions as how best to apply it, had been provided by the MoFA FLS. This situation was by no means uncommon and there is obviously an urgent need to re-educate the front-line staff to prevent further misuse of this fumigant.

Whilst several farmers complained of headaches after fumigating grain with phosphine, there were no reports of more serious effects. Such poor practices are not only unsafe for the farmers but can create conditions favourable to the evolution of resistant populations of insect pests. A successful fumigation requires a concentration of at least 150 ppm (0.2 mg/l) to be maintained for a minimum of five days to ensure control of all developmental stages of insects (Taylor and Gudrups, 1996). Phosphine fumigations using similar jute "maxi" sacks (each containing 100 kg of maize) were carried out at SARI (Brice and Ayuba, 1996). One phostoxin tablet was used per unlined sack of maize. The gas generated in the sacks escaped so rapidly that concentrations did not reach 150 ppm and by 48 hours the gas had been completely lost. Repeated exposure of insect populations to low concentrations of phosphine has been demonstrated to permit the selection of resistant strains of insect pests (Mills, 1983 cited in Taylor and Gudrups *et al*, 1996). The application method practised in Ghana at present (2-3 tablets per sack) is likely to kill most of the adult insects. However, the immature stages found within grains will probably be unaffected and will emerge at a late date to re-infest the store. These insects, and their progeny, which have been subjected to sub-lethal dosages during their immature stages, may develop resistance to phosphine.

The true efficacy of the phosphine fumigations carried out in the villages visited is therefore unclear. If sacks of maize are heavily infested with insect pests they will have to be fumigated repeatedly to kill the succession of adults emerging from the kernels. Comparing the efficacy of a particular plant material as a protectant, with the fumigant phosphine, must therefore be subject to a certain degree of caution.

POTENTIAL CONSTRAINTS TO THE USE OF PLANT MATERIALS

Cost

Cost was defined as the immediate cost of the structure together with time and effort required. Of the seven factors listed, cost was ranked as the single most important factor affecting the choice of protection method (Table 4). The cost associated with the use of plant protectants ranged from mean scores of 2 to 10 (where 1 represented the most expensive to use and 10 the least expensive (Table 5)). However, when the combined mean of these scores was calculated (6.9), the majority of plant protectants appeared to be relatively inexpensive to use. The combination of shea nut oil residue and chilli pepper scored the highest, and hence most inexpensive protection method; this figure, however, is rather misleading as only one village used this treatment. Out of the plant protectants employed in more than one village, kim-kim and shea nut residue were the least expensive, followed by neem, kola plant, general plant protectants, chilli pepper, lodel and Mahogany bark.

The two remaining plant protectants, kul-enka and orange peel, were considered expensive to use. The grass kul-enka was often difficult to find so its collection was perceived by the farmers as costly in terms of time and effort. The relatively low mean score for availability confirmed that local availability was indirectly influencing the cost farmers associated with the use of this plant protectant. Orange peel was also considered expensive to use as a storage protectant. The high price also reflects availability since oranges are grown predominantly in the Brong-Ahafo and Ashanti regions of Ghana.

Among the other protection methods, the inert materials (ash, smoke and sand) were awarded the highest, and hence cheapest, scores. All of these substances are readily available and do not involve any purchase costs. The most expensive protection methods were, as expected, the chemical preparations Actellic, phosphine and DDT. Calcium carbide (CaC_2) was also considered expensive to use. There is a large demand for calcium carbide to use in hunting lamps and for welding and so it therefore commands a high market price. Calcium carbide was only mentioned in one village

(Yipala, NR); its use is extremely dangerous as it is readily decomposed by water to form a highly flammable gas (acetylene C_2H_2).
Availability

Plant protectants were given mean scores ranging from 1 to 7.7 in this category; the combined mean of these scores (5.8) indicated that plant protectants are relatively available compared with other protection methods (Table 5). Orange peel was again the only exception, as previously mentioned, oranges are not grown in Northern Ghana.

The highest mean scores, and hence most readily available, were awarded to the inert materials ash, smoke and sand. Availability was identified, along with cost, as being one of the main constraints to the use of chemical insecticides - Actellic, phosphine and DDT.

Access to chemical insecticides was not always restricted, farmers living in villages in close proximity to a market could easily obtain chemicals. If the farmers could produce sufficient crop to sell, the accessibility of the market also allowed farmers to sell their produce to provide revenue for purchasing chemicals.

Case study

The villages of Bulenga and Bamahau are situated only a few kilometres from Wa, the largest market town in UWR. Three out of four farmers interviewed in Bulenga used Actellic to protect their stores from insects. The majority of the farmers in Bamahau also used Actellic. They all appeared relatively unconcerned about the price or availability of insecticides. Large-scale farmers were able to sell a sack of produce to buy the chemicals. Whilst cost was still a constraint to small-scale farmers, the average farm size in both villages was above 10 acres so it can be assumed that a large proportion of farmers would be able to produce enough to sell and hence buy chemical insecticides.

Toxicity

Toxicity was defined as the safety of a protection method in terms of its risk to human health. Although ranked 4th in importance, toxicity was only mentioned in seven of the 20 villages questioned about storage protection. Plant protectants were perceived by farmers to be relatively safe to use (combined mean score of 7.3). Only one reference was made, by farmers from the village of Brutu in UWR, to the potential toxicity of certain plant protectants. The farmers from this village utilised ash and three different plant protectants, the choice of which was determined by their toxicity and the time period of storage. If the commodity was to be eaten immediately, ash was mixed with the commodity; if it was not to be eaten for a week or more then dried chilli peppers were added instead. If the commodity was not required for at least three months then the farmers would apply dried leaves of lodel but if the commodity was to be stored for approximately four months or more before consumption, the farmers used dried neem leaves to protect their harvest. The effectiveness of each of these protective methods was obviously considered but it appeared that the toxicity of the residues left in the produce after treatment strongly influenced the farmers choice.

Seven out of the 20 villages visited expressed concern about the toxicological (human) effects associated with the use of chemical insecticides. The use of Actellic, phosphine and DDT was considered unsafe. Farmers from these seven villages, if they used chemicals, would only apply them to commodities kept for seed and not consumption. Others would only consume treated produce after a period of three months or more in storage when the effects of the treatment were thought to have disappeared.

The inert protectants, ash, sand and smoke were considered safe to use with mean scores of 7, 9.5 and 10 respectively.

Ease of use

The mean scores awarded for plant protectants in this category ranged from 3 to 10. The combined mean (6.4) indicated that plant protectants, in general, were relatively easy to use. However, those plant protectants requiring greater amounts of preparation prior to use were awarded lower mean scores than those requiring less. The shea nut residue and neem seeds had to be pounded before use (although shea nut residue is a by-product of the processing of shea butter). The leaves of lodel did not require such extensive processing but availability may have influenced the farmers perception of usage. Although the plant's availability was scored relatively high it was described as difficult to locate in several of the villages, including Brutu in UWR. The plant protectant, Poni, was included in the general grouping of plant protectants. The root of this plant is used for protecting stored products. It is dug up, ground to a powder and dried before being mixed with the produce. This lengthy procedure was perceived as a constraint by farmers in Bulenga, UWR. The preparation of neem leaves, kim-kim, chilli pepper, and shea nut & chilli pepper, however, required considerably less effort. The products could be easily harvested from the growing plant, dried and simply sprinkled with the stored commodity. Interestingly, the combination of shea nut residue and chilli pepper received a conflicting score to that awarded to shea nut residue alone. The village using the combined treatment did not associate the production of shea nut residue with any extra effort, it was simply a by-product of an everyday process.

> ***Case study with farmers from Bamahau village in UWR***
> *Preparation time was cited as the main constraint to the use of mahogany bark in Bamahau (village 18). The bark is a traditional storage protectant which, although no longer used, is thought to be as effective as chemical insecticides (which are used extensively in the village). The farmers are reluctant to use it because of the large amount of powdered bark that would be required. Its use could only be considered if there were some kind of machinery made available to process the bark. With the village's proximity to the regional market, and the availability of sufficient funds, chemical insecticides were a much more attractive alternative.*

Chemical insecticides were considered the most difficult to use out of all the protection methods considered. This was fairly surprising as the use of insecticides, Actellic in particular, is relatively easy; the powder requires no pre-treatment unlike many of the plant protectants and can be simply sprinkled in with the produce. Although many of the farmers interviewed had never used insecticides and therefore had to estimate the degree of difficulty associated with their use, many had either seen, or heard of, how it was used. However, farmers may have over estimated the difficulty of using unknown, man-made chemicals.

Acceptability

Farmers considered a particular protection method to be "acceptable" if they were comfortable using it. With the exception of chemical insecticides introduced by the MoFA extension officers or market traders, protection methods employed in northern Ghana were traditional, and as such, highly acceptable to the farmers. The use of these traditional practices was usually not questioned and in many cases our visit was the first time farmers had actually considered the reasons for using a particular practice.

The acceptability of the different plant protectants ranged from 1.5 to 10 with a combined mean score of 5.7. It should be noted that acceptability was mentioned in only five villages.

Case study with farmers from the village of Zakari Yili in the NR (village 1)

Farmers knew of the use of neem seeds and chemical insecticides as storage protectants but had never used them. They were asked to estimate the various attributes of using these methods to protect their stores.

Matrix for storage protectants:

Factor	Rank	Shea residue and peppers	Smoke	Chemicals	Neem seeds
Cost	1	10	4	0	8
Availability	2	6	8	0	8
Ease of use	3	10	8	0	10
Effectiveness	4	10	8	7	6
Acceptability	5	10	8	6	6
Versatility	6	9	6	10	8

Although farmers knew chemicals and neem to be extremely effective, they were reluctant to give higher scores for efficacy because they had never used them. They also gave chemicals a score of 0 for cost, availability and ease of use because they had not used them. When they were asked to choose the best protection method, the farmers picked shea nut residue and chilli pepper because they know it is effective and they have always used it (i.e. very acceptable). However, they were still very keen to try chemical insecticides and the neem treatment if they could be made available, and in the case of the insecticides, also made affordable. It appears that tried and tested traditional storage practices will probably always be preferred but if a novel method is known to be effective then farmers will be happy to try it provided it does not involve high costs.

During the field-work, the roles of tradition and ethnicity in determining "acceptability" was a recuring theme. One important element of this was the extent to which local knowledge could be exchanged between different tribal groups. Findings were mixed:

a) Although some methods were common to several villages (Table 4), many of the plant species used to protect stored products were unique to a village or tribal group. It is difficult to ascertain if the use of these plants species arose separately in the villages or through acquired knowledge.

b) In Achubumyor, tradition appeared to present a barrier to the exchange of protection methods between tribes. This village (or settlement) comprised a number of different tribal groups: the Dagati; Dagomba; and Gonja. Whilst the Dagati's were able to store cowpea and bambara groundnuts for seed, insect damage prevented members of the Gonja tribe both from storing cowpea for any length of time, and from growing bambara. Although the Gonja's knew that the Dagati's used ash to protect their stored crops, they had never tried using it because it was not traditional. They also appeared reluctant to ask a member of another tribal group for instructions on how to use ash.

c) The exchange of knowledge between villages and tribal groups can be demonstrated with the use of ash. Farmers throughout the three northern regions of Ghana use ash to protect their stored crops. It is normally mixed with the commodity to be stored in a ratio of approximately 2:1 (ash to commodity) but there were several variations to its use in the UER. The villages of Bumboazio (close to the UER border), Bongo-Soe, Nangalikinia, Booya and Piaga-Chiok roasted the commodity with ash over a fire before the two were mixed and stored in the usual way. As no single tribe was common to each of these villages it would appear that local knowledge had been exchanged between tribal groups at some stage.

Versatility

The versatility of each protection method was defined as its potential to protect a number of different stored commodities. The versatility of plant protectants ranged from a mean score of 4 to 10. The combined mean score for plant protectants (6.8) indicated that farmers considered them to be relatively versatile in their usage. Mahogany bark, shea nut residue & chilli pepper and kul-enka were perceived to be extremely versatile. Mahogany and the shea nut combination, however, were only mentioned in one village. Of the plant protectants used in more than one village, kul-enka was considered the most versatile and was used in these villages to protect a number of different types of commodity.

Chemical insecticides(Actellic in particular) were also considered extremely versatile. The least versatile method of storage protection was the use of smoke, that was restricted to protecting maize cobs kept for seed. It is important to note that versatility was ranked lowest of all the factors considered and was only mentioned in six villages. The relative importance of a protectant's versatility is therefore less than factors such as cost and efficacy, which were ranked higher and mentioned more frequently.

CONCLUSIONS

Farmers viewed pest control as an important area in the storage of grains throughout northern Ghana (NR, UER and UWR). Methods employed by farmers to protect stored crops against insect attack consisted of inert, plant and synthetic materials. Whilst there was considerable variation, certain plant materials used as protectants (e.g. lodel and chilli pepper) were given high scores by farmers against criteria which they felt were important in determining their choice of protectant.

The use of plant protectants was widespread throughout the three regions. Seventeen out of the 20 villages visited used plant materials to protect their stored produce against insect damage. However, it should be noted that only a few of the species were common to more than 2 or 3 villages. The most widely used plant protectant was found to be kim-kim (reported in 6 villages) followed by chilli pepper (5 villages), lodel, shea nut residue and neem seeds (all 4 villages). The villages where a particular protectant was found tended to be grouped together (although there were exceptions). For example, all but one of the villages in which kim-kim was found were in the eastern part of northern Ghana - indeed, plant protectants were more likely to be used in the eastern side of northern Ghana (UER and eastern NR). These areas are generally less affluent than the other parts of the north, and plant protectants appear to provide a valuable alternative to the use of expensive, and often unavailable, conventional insecticides.

Whilst the use of a particular plant material is obviously primarily linked to its local availability, tribal custom plays an extremely important part in its use. It was common to find neighbouring households, of different tribes, using different plant materials.

RECOMMENDATIONS:

The fieldwork findings have thrown-up several issues which will need to be addressed, both during the current plant materials project, and in the planned second phase of the project (vis project memorandum). Introduction of suitable plant materials may be at two levels: the use of a locally growing plant for tribal groups not currently using this material; and, the introduction of plants from one geographical area into another. It is **recommended** that the following areas are incorporated:

1. The comparative advantage of introducing plant protectants to areas where they are currently not in use should be critically examined. One of the clear implications of the field work is that farmers may have good reasons for using or not using particular plant materials. For example, level of affluence appears to be an important factor behind the differences in use of plant materials between eastern and western parts of the north. If this situation continues then the implementation of the project should be focused on the east of the NR and the UER in the first instance, where plant materials appear to be most widely used and where the demand for such materials is likely to be highest.

2. An environmental impact assessment must be undertaken before any plant materials are introduced into an area where they do not normally grow. This is to avoid undesirable effects such as introduced plants becoming weeds or acting as host plants for diseases and insect pests.

3. Eventual extension of new or existing plant types should focus on the cost, effectiveness, availability and ease of use issues associated with the use of plant materials. Emphasis should be placed on the advantages of using plant materials in relation to these issues.

Chapter 5
STORAGE STRUCTURES

The objectives of this part of the survey were to determine the storage problems faced by the farmer, and therefore their needs in terms of storage facilities. The survey assessed the extent to which existing storage structures, including mud silos, meet these needs at present by examining the strengths and weaknesses of the different store designs. Attention was also paid to structures such as the Mamprusi mud silo, which is being introduced by the MoFA. Comparisons were made to those store types currently used. The effectiveness of the structure (protection against moisture, insects, termites, theft, etc.), and the potential constraints to the further adoption of mud silos, such as the Mamprusi design, (cost and ease of construction, availability of materials, etc.), were addressed.

IDENTIFICATION OF STORAGE STRUCTURES

Details were collected on the stores used within the 23 villages visited during the survey (Table 7). Many different designs were identified - the great variability being due, primarily, to the strong traditions within the many tribal groups in the three regions. For convenience, the stores were grouped into several basic designs, ten of which were selected for subsequent analysis (Table 7).

Table 7 Storage structures used throughout northern Ghana

Code	Store Type	Local name	Village	Description
A	Mud silo 1 **(MAMPRUSI)**[a]	no name Bule Lipil Buga[b] Bugi[c]	2, 3, 4 5 7 10, 11 11	Spherical shape on three or four legs (as introduced by MoFA)
B	Mud silo 2[a]	Bui Tula **BAARE** Baari Bood Bwr	19 20 20 21 22 23	Cone shaped, built on a layer of stones and/or poles. Free-standing outside of any other structure.
C	Mud silo 3[a]	Katari[d] Bowr[e] Bowryari[e] Vuri[f]	12 12, 17 12	Square or circular, built within a room (or under a flat roof), tapering to a neck protruding through the roof (access via the roof)
D	Mud silo 4[a]	Namvuri[g]	14, 16	Usually rectangular, outside of the house, floor raised 0.5m above the ground (with fowls below), made from bricks, up to 3m tall.
E	Mud silo 5[a]	Buo Katanga (larger Buo) Bowrpla	13 13 17	Small, often egg shaped, usually portable store. Often sealed at the top with a small opening in the side.

F	Wooden framed, thatched	**KAMBONG** Kpacharaga Chenchunkum Chenchenlenkung Napoo Sigi Brugu Ganga[h] Pulu Narpaug	1, 2, 3, 5, 6 4, 6, 7 6 7 8 10 11 13 16 23	Wooden frame work with 'Zana' matting (woven sorghum matting) floor and walls. Floor traditional ½m off the ground (MoFA 'improved' Kambong is raised 1½m above the ground for improved rodent resistance)
	Floorless, wooden framed, thatched	Sogli	6	Same as Kambong but without a raised floor (produce stored on the ground)
	Conventional hut	Libuul	7	Same as the hut in which the villagers live
	Small hut	Napogu	6	Small mud hut with raised platform, covered with Zana matting
G	Raised Platform	**LINGA** Kikaafil Capala[h]	1, 3, 5, 6[i], 8 7 10	Platform made from wooden poles (often with matting from sorghum stalks), raised 1½ to 2 metres from the ground. Area underneath often used as a shaded meeting place.
H	Baskets: (i) Unplastered (ii) Plastered	 **KUNCHUN** Chenchunkum Napogu Pege Sampaa(?) Yikori Koyonko Naparg[j] Chenchunkum Pupuri Kunchun (Kupong) Kosorgu Yikori	 1, 3, 7, 8 2 2, 4 11 13 19 21 22 1, 2, 5[k] 2, 4, 5[l] 6[i] 13, 23 19	Basket made from sorghum stalks. Usually placed on a raised platform or Linga. The name usually describes the basket itself (which is then placed on a Linga) but occasionally the name indicates the whole thing (including the Linga). Sometimes there are separate names for those plastered with cow dung and those that aren't. Other times the same name is used whether or not it is plastered. Baskets usually plastered when storing smaller grains such as millet and sorghum (or for insect control?).
	Temporary structure	Sinklepohingu	8	Boat-like structure made from ropes and grass
I	Fired clay pots	most villages Singi Simme Dugu Vijen Dokoh Yor (small) Duk (large)	 11 12 13 14 21 22 22, 23	
	Enclosed raised platform	Seri[m] Yam barn (Pilawe)	12 14	
J	Jute sacks		2, 4, 6, 8, 10	
	Bottles		22	Glass bottles for thermal disinfestation and storage of seed

Villages 1 to 5: Tamale area; 6 to 8 eastern NR; 9 to 12 western NR; 13 to 18 UWR, and; 19 to 23 UER.

[shaded box] Five principal types of store discussed throughout this chapter

[a] Another advantage with the mud silo is the confidentiality - people don't know how much you have (village 8).
[b] Buga have no compartments whilst the Bugi[c] have compartments
[d] Outside, under a Linga type roof
[e] Both are inside the room, the Bowryari has one compartment whilst the Bowr has several (also totally inside including the opening).
[f] Vuri is the general name for the mud silo - Bauvuri (large Vuri), Manvuri (small Vuri)
[g] The Namvuro is made from mud bricks and for this reason is less sturdy than the mud silo (village 15)
[h] On farm storage structures as opposed to in the living compound
[i] A Kunchun placed on a Linga is called a Kupong in village 6
[j] Large container rather like a Kambong but without the wooden supports therefore classed as Kunchun
[k] Used for large quantities of rice, compared with [l] for small quantities of rice (different names for smaller and larger structures of the same type)
[m] Linga with closed sides in which yams are stored

Although 5 types of mud silo were described, only two types (A and B) were examined to any extent - types C, D and E were therefore ignored during the following discussions. Since the capacity of the fired clay pots is limited when compared to the other types of stores, they tend to be reserved for either small quantities of grain or temporary storage for immediate consumption. For this reason, they have also been ignored during the discussion. The same applies for jute sacks except for, in a few cases, where they have replaced existing types of stores.

Five principal stores are therefore compared: the Mamprusi mud silo; Baare mud silo; Kambong; Linga; and Kunchun stores (types A, B, F, G and H in Table 7, illustrated in Figures 3 to 6). Capacities, expected life, costs of construction etc. are listed in Appendix 4.

Figure 3 Mamprusi mud silo

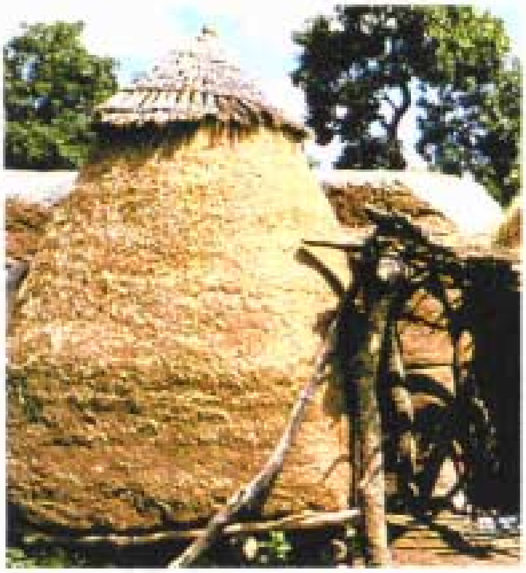

Figure 4 Baare mud silo

Figure 5 Kambong

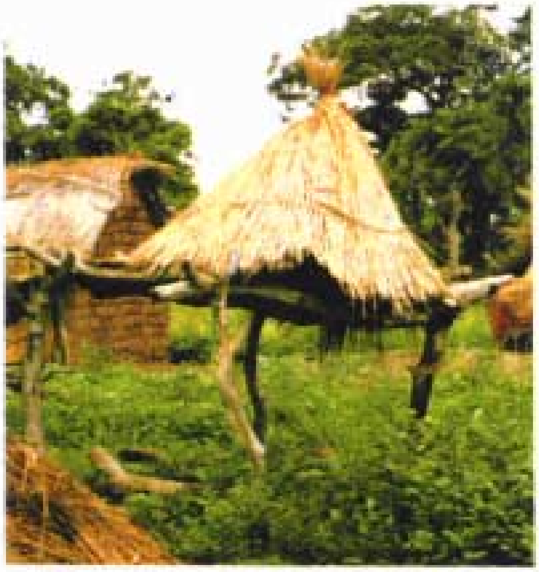

Figure 6 Linga (platform) with a Kunchun (basket) covered with thatch

IDENTIFICATION OF STORAGE FACTORS AND SCORING OF STORES

Villagers were asked to do three things. Firstly, they were asked to list the factors they would consider when selecting a store. Secondly, they were asked to rank these factors in order of importance. In the ranking exercise, a score of 1 was best, 2 next best and so on. Finally, they were asked to score each type of store against each of the factors (on a scale of 0 to 10: 0 being poor, 10 being excellent).

(i) Storage factors: A total of 15 factors were mentioned in 16 villages (not all of the 23 villages visited were asked about storage factors). The factors tended to fall into two groups: those concerned with the technical effectiveness of the storage structure (i.e. how well they protected the grain), and those factors concerned with the constraints to the adoption of the structure with regards to final uptake by farmers (for example cost of the structure, ease of use, availability of materials).

(ii) Ranking: The storage factors were ordered according to their mean ranking (Table 8). The frequency that each factor was discussed (i.e. the number of villages in which that factor appeared) is also listed in the Table.

Table 8 Ranking of Storage Factors influencing the type of Storage Structure

Factors	Categorisation[11]	Mean Ranking[12]	Frequency[13]
Protection against insects	E	1.5	13
No. of crops	A	2.5	6
Protection against termites	E	2.7	3
Protection against rodents	E	3.1	11
Protection against rain/water	E	3.4	7
Store capacity	A	3.5	4
Life of the store	A	3.6	9
Availability of materials	A	3.8	12
Ease of construction	A	3.9	11
Protection against theft	E	4.1	10
Acceptability (ethnic?)	A	4.3	4
Cheapness of stores	A	4.6	9
Protection against fire	E	5.0	3
Ease of use	A	5.0	6
Maintenance	A		1

11 Factors were grouped into two categories: those factors concerning the Effectiveness (E) of the structure; and, those factors concerning the constraints to the Adoption (A) of the structures.

12 Mean ranking applied by the villagers: 1 is best.....

13 Frequency relates to the number of villages in which this factor was raised.

The number of times that any particular factor was raised did not necessarily relate to its importance as ranked by the villagers. For example, whilst "protection against insects" was the most frequently mentioned factor AND it was ranked as the most important factor, "protection against theft" was the fifth most frequently mentioned factor but was ranked ninth in importance.

(iii) Scoring of store types against factors: Scoring of each type of store against the various storage factors produced a matrix of scores for most villages. The mean, number, standard deviation, and median of the scores for each of the store types were calculated (Appendix 4). The mean scores and the frequency of their occurrence are reproduced in Tables 9 and 10.

Table 9 Mean Scores of Storage Structures against the Storage Factors

Factors	Store types									
	A	B	C	D	E	F	G	H	I	J
Technical Effectiveness of the Structures:										
Protection against Rain/water	9.8	6.0				6.5	2.0	4.2	8.5	4.0
Protection against Insects	9.0	5.8				4.4	4.6	4.9	7.5	1.5
Protection against Termites	7.0	4.0						1.5	8.3	5.0
Protection against Rodents	8.6	5.0				2.5	2.8	4.9	7.0	5.5
Protection against Theft	8.7	10.0		3.0		3.6	3.7	3.4	5.8	1.7
Protection against Fire	10.0	9.0				3.3		2.0	10.0	3.0
Potential Constraints to the Adoption of Structures:										
Ease of construction	5.0	6.3	6.3			6.1	8.0	5.1	6.7	0.7
Availability of materials	4.8	6.8				5.8	5.2	6.1	5.5	3.5
Ease of use	4.0	4.3				5.6	7.5	5.7	8.3	5.5
Maintenance	10.0					2.0		2.0		
Life of the store	9.6	8.4		7.0		3.4	1.3	3.0	8.3	3.3
Acceptability (ethnic?)	9.5	5.5	6.8			6.0	4.0	4.5	6.7	1.0
Cheapness of stores	4.7	4.5				5.1	7.7	3.6	6.4	4.0
No. of crops	9.2	8.0		5.0		7.6	3.0	2.0	8.0	7.5
Store capacity	6.3	10.0				7.0	7.0	1.7	3.0	2.0
MEAN SCORES	*7.7*	*6.7*	*6.5*	*5.0*		*4.9*	*4.7*	*3.6*	*7.1*	*3.6*

where: 'A' is the Mamprusi mud silo
'B' is the Baare mud silo;
'C' is the Square/circular mud silo with narrow neck passing through the roof;
'D' is the brick built square silo;
'E' is the Buo portable mud store;[14]
'F' is the Kambong;
'G' is the Linga (raised wooden platform);
'H' is the Kunchun;
'I' is the fired clay water pot;
'J' is the jute sack.

[14] No data was collected during the survey on this type of store.

Table 10 Frequency that each type of Storage Structure was scored against the Storage Factors

	Store types									
	A	B	C	D	E	F	G	H	I	J
Technical Effectiveness of the Structures:										
Protection against Rain/water	5	2	0	0	0	4	1	5	4	2
Protection against Insects	12	5	0	0	0	12	5	11	6	4
Protection against Termites	1	3	0	0	0	0	0	2	3	1
Protection against Rodents	10	2	0	0	0	9	4	9	4	2
Protection against Theft (security)	8	2	0	1	0	8	3	5	4	3
Protection against Fire	2	1	0	0	0	3	0	2	2	1
Potential Constraints to the Adoption of the Structures:										
Ease of construction	9	4	1	0	0	8	3	8	6	3
Availability of materials	11	5	0	0	0	10	5	10	6	4
Ease of use	4	3	0	0	0	4	2	3	3	2
Maintenance	1	0	0	0	0	1	0	1	0	0
Life of the store	7	5	0	1	0	6	3	7	6	4
Acceptability (ethnic?)	2	2	1	0	0	1	1	2	3	1
Cheapness of stores	6	4	0	0	0	6	3	7	5	4
No. of crops	5	1	0	1	0	5	1	3	2	2
Store capacity	3	1	0	0	0	4	2	3	1	1

TECHNICAL EFFECTIVENESS OF THE STRUCTURES

'Technical effectiveness' of the store was measured by the scores obtained for the protection against rain/water, insects, termites, rodents, theft (security) and fire (Table 9). Although there were only six factors concerned with the effectiveness of the structure, compared to nine factors concerned with the constraints for adoption, ranking of these factors revealed that four of the five top ranked factors were concerned with the effectiveness of the structure (Table 8). It should be noted, however, that most of the villagers did not possess a Mamprusi store but were giving their *impressions* of the store's performance. In some villages where the MoFA had introduced one or more silos (for example, villages 1 to 5) the farmers had been able to view and discuss the Mamprusi mud silo, and so, whilst they may not have actually used one, were aware of construction and management details. In other villages, however, most of the farmers had not seen a Mamprusi silo but were aware of its existence and, in some cases, that the MoFA were encouraging farmers to use them.

Protection against insects

The Mamprusi mud silo was viewed as being the most effective of all the stores examined with regards to protection against insects - the most important AND the most frequently mentioned storage factor. Whilst the Baari store was far inferior to the Mamprusi design, it was still considered as providing better protection against insects than the Kambong, Linga or Kunchun.

The protection afforded by the Mamprusi silo was presumably due to the physical barrier imposed by the mud to the ingress of insects. Despite the obvious need to seal the store to maximise the barrier to insect infestation, sealing of the openings at the top of the silos varied considerably between villages. Whilst mud lids were recommended for use on the Mamprusi type silos (and were present in several cases), many of the Baari type silos were fitted either with covers woven from sorghum stalks (UWR), or with wood or metal sheets (UER) - providing little protection against insect attack. Several stores, for example those found in village 21, did not use any form of lids under the thatched cover.

Protection against termites

Of the five factors concerned with the effectiveness of the structure, the Mamprusi silo scored most poorly on the protection against termites. However, since it still scored 7 out of 10, the Mamprusi silo still appeared to provide a reasonable level of protection, especially when it was compared with the far lower scores of 4 and 1.5 for the Baare and the Kunchun (the Kambong and the Linga were not used in the villages where protection against termites was scored).

Although storage structures were only scored against their protection against termite attack in three of the 23 villages visited, problems with termite attack were mentioned in 13 of the villages. Termites appeared to be a problem not only in UER (as had been thought prior to this survey), but throughout the three regions (villages 2, 5, 7, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23)[15]. However, the severity of the problem clearly varied through the regions, with the UER suffering more acutely than the other two regions (as suggested by Golob *et al*, 1996).

> ***Although the problem with Termites was more acute in the UE region, occasionally severe problems were encountered elsewhere:***
>
> *Termites were such a problem in village 18 (UWR) that farmers had stopped using mud silos and were currently using jute sacks. They stated that they would return to mud silos only when they were confident that the termite problem had been cured.*

The problem with termites in UE extended to all types of structure including living accommodation. Whilst they were obviously a problem with wooden structures, severe infestations could also destroy mud structures. In village 12, when infestation becomes particularly severe, the produce is removed and a fire then lit inside the store. If this does not solve the problem the structure is removed and a new one built (often on the site of the old one!!). Termite attack was reported to be more of a problem in the wet season (village 12) when the damp mud becomes easier for the termites to burrow into (village 19). Apart from using expensive chemicals, the only 'natural' treatment appeared to be with seed from the 'Vitso' tree (village 10). The seed is soaked in water overnight to produce a black, bitter solution which is mixed with the soil as the silo is constructed. When asked about storage problems, villagers claimed that termite attack was not a problem because they use this plant. Availability of the seed is a problem since the tree is difficult to find and the seed is only available at certain times of the year. Farmers in village 14 claimed that termite damage is

15 The most severely affected villages being underlined in this list of villages.

reduced if silos are made from the same clay as that used for producing clay water pots.

Protection against rodents

The protection afforded by the storage structure to rodent attack was mentioned almost as many times as protection against insect attack (11 times compared with 13 for insects). Again, the Mamprusi mud silo appeared to provide by far the best protection against rodents, its strength being the physical barrier imposed by its mud walls. The Baare mud silo, although not appearing to be as effective as the Mamprusi silo, still out-performed the Kambong, Linga and Kunchun stores. No examples of the 'improved Kambong' (raised approximately 1.2 m off the ground, with the legs being fitted with rodent guards) were encountered - the scoring was wholly concerned with the traditional design (the floor being raised approximately 0.3m off the ground with no protection against rodents).

It was noted in village 11 that, when rodents make holes in the structure of the store, these act as entry points for water and insects, leading to secondary problems. By far the most common method of rodent control was the use of phosphine in those villages where aluminium phosphide tablets were affordable and obtainable.

Protection against rain/water

Protection against rain/water was only mentioned in approximately 20% of the villages surveys. The mean score in those villages where it was ranked was 3.4; the fifth highest mean score.

The Mamprusi silo scored almost full marks indicating that it was highly effective in protecting the grain against either rain water or ground water - far greater than any of the other types of store. The second best store was the Kambong, followed by the Baare, Kunchun and the Linga.

This factor was one of the few where the Baare silo scored lower than one or more of the other store types (other than the Mamprusi silo). Good quality thatch of the Kambong store obviously provides good protection to the grain. Examination of the coverings over the inlets on top of the Baare silos seen in the villages (usually either a few wooden boards or metal sheets balanced on top of the silo) indicated that poor protection of the inlet is probably the main cause for concern. The introduction of a properly thatched cover to the Baare silo (similar to that on the Kambong) would undoubtedly reduce the risk of rain water entering the store. It should be noted that some Baare silos, especially in UER, were temporarily covered with long grass during the rainy season. However, this was primarily intended to reduce water erosion to the outer sides of the structure rather than prevent rain entering the silo. The other possibility is the uptake of moisture from the ground. Given that the base of the Baare silo is the widest part of the structure and, although built on a layer of stones, much of the base is in contact with the ground and movement of water from the ground into the structure would certainly be possible. Since the Kambong store is raised on short legs, movement of ground moisture into the structure would be negligible, which could account for its higher mark. However, if this were the cause, the Baare silo would be likely to perform extremely poorly and so one would have expected the difference in scoring between the Kambong and the Baare stores to be far greater. The only indication that groundwater may be a problem was in Piaga-Chiok (village 19 in UER) where, due to low lying areas, water-logging makes the mud structures damp and, in some cases, the structures eventually sink necessitating rebuilding.

None of the walls of any of the structures reviewed are impervious to water and so the moisture content of the grain in any of the stores will be influenced by the ambient RH (mentioned in several villages). Evidence of this was noted by Brice during a previous visit to the area where an over-filled Mamprusi mud silo (in Achubumyor village, also visited during this survey) had been damaged by the grain swelling as its moisture content increased during the wet season. A similarly damaged store was seen in Brutu (village 17) during the survey. The carry-over of fungal spores on the walls of the mud silo from one year to the next was mentioned in the Project Memorandum as a potential problem for investigation (based on work in Benin). Although this was only mentioned in one village (Gbenja, village 7), given that this problem is not always obvious, it is likely that the problem is more widespread.

> *Farmers in village 23 stated that the barns absorb moisture during the wet season, increasing the humidity and therefore moisture content of the grain inside. This is a particular problem with early millet (and early maize, Golob et al, 1996) in storage at this time.*

Thorough drying of the commodity prior to storage was stated to be of utmost importance to avoid problems in some of the mud structures - in particular in the Bugi and Bugu in village 11. Drying was also mentioned in some villages in connection with pest control (discussed further in Chapter 4, Plant Materials Project). However, this drying was only possible with late maturing varieties and when theft is not a problem in the fields (for example, village 9).

Protection against theft

Problems with security (against theft) is common not only during storage but also prior to this during the conditioning stages when the commodity is left in the field to dry, before being placed into store (villages 8 and 13).

The security of a particular structure is partly due to the structure itself but is also due to its location within the village - stores that are removed from the living area are obviously more at risk than those within. In scoring the different structures attempts were made to 'isolate' the structure from its surroundings. The best structure for security was the Baare mud silo, scoring a maximum of 10 out of 10 (however, the Baare was only scored in two villages). The Mamprusi silo was classed as being very secure, whilst the Kambong, Linga and Kunchun stores were equally poor.

Due to its bulkiness, theft of unthreshed grain is less of a problem than with the threshed commodity (village 11). Theft is not limited to outsiders - theft by the women of the household was occasionally mentioned (village 13).

Protection against fire

Although mentioned in several villages structures were only scored for protection against fire in three of them. It was particularly important in those villages to the east of Tamale (villages 6 and 7) where so much of their produce had been lost through fire during the conflicts in 1994.

Mud silos were classed as being vastly superior to non-mud structures for protection against fire. The Mamprusi and Baare silos were scored at 10.0 and 9.0 respectively, compared with 3.3 for the Kambong and 2.0 for the Kunchun types (the Linga store was not scored against this factor).

Overall, the mud silos, especially the Mamprusi type, were regarded as being far more effective at protecting commodities than the Kambong, Linga and Kunchun stores.

POTENTIAL CONSTRAINTS TO THE ADOPTION OF THE ADOPTION OF ALTERNATIVE STORAGE STRUCTURES

Nine of the 15 factors listed by the villagers were classed as potential constraints to the adoption of an alternative storage structure. Although many of the factors concerned with the effectiveness of the structure were ranked more highly (Table 4), the 'number of crops' that a store could hold at any one time was ranked as the second most important factor. Although reference is made in the following sections to the constraints to the adoption of the Mamprusi design, these should be viewed as potential constraints to the adoption of small mud silos and not specifically to the Mamprusi design.

Number of crops

The 'number of crops to be stored' refers to the number that can be placed in the store at any <u>one time</u> and NOT to the range of crops that could be stored over a period of time. The scores for the Mamprusi and Baare mud silos, along with that of the Kambong, were high, especially when compared to the Linga and the Kunchun types. This may be due to the typical size of the structures - the mud silos and the Kambong store being of similar size to each other whilst the Linga and especially the Kunchun types are smaller. The number of crops that can be stored at any one time is also a function of the shape of the space within the store - the vertical sides of the Baare and the Kunchun stores, and the ability to sub-divide the internal space of the Mamprusi silo, facilitates the storage of more than one type of crop at a time.

Store capacity

The matrix scoring indicates that the Mamprusi store was thought to be limited with regard to its potential storage capacity when compared to the Baare silo, the Kambong and the Linga stores. However, as already stated, the villagers were comparing the types of store currently used to the Mamprusi silo that they had seen introduced into other villages by the MoFA. Since these Mamprusi silos tend to be rather small the problem over storage capacity is probably less than the scores suggest.

Life of the store

The Mamprusi and the Baare mud silos were both long lasting, especially when compared to the Kambong, Linga and Kunchun structures. Whilst this appeared to make sense with most of the structures, it was unclear why the Linga (basically a platform constructed from, in many cases, substantial sized poles) should score so badly - especially since many of the Linga stores seen during the survey were obviously many years old. It was concluded that, when considering the life of the Linga store, the villagers were referring to the thatched covering and matting below and above the commodity. The scoring (with the exception of the Linga store) agreed with the data collected on the typical age of the different structures (Appendix 4) which is summarised in Table 11.

Table 11 Typical lives of the five main types of stores

Store type	Typical age
Mamprusi mud silo	up to 50 years
Baare mud silo	> 15 years
Kambong	up to 10 years
Linga	up to 30 years
Kunchun	up to 15 years

Data extracted from Table A4.5

Availability of materials

Generally, the scores were low for all stores with regard to the availability of materials. The Baare mud silo appeared to be least affected by the availability of materials, followed by the Kunchun, Kambong, Linga stores and Mamprusi silo. Mamprusi store construction is constrained by the need to use termite soil and a particular type of grass for binding the mud; the Baare silo uses neither of these materials but relies on normal soil alone. Whilst wooden poles are sometimes used in the base of the Baare silo, few are used and appear not to be a constraining factor - poles are a constraining factor in the Kambong store due to the larger number required. The main problem with constructing the Mamprusi silo appears to be with the additives used to increase the 'binding strength' of the mud. Occasionally, shortage of specific grasses was also reported to be a problem. However, most villagers tend to restrict themselves to using one particular additive, and are often ignorant that other, possibly equally effective materials, may also be easily available. Identification of different materials, along with effective extension could address this deficiency. The availability of specific materials varies from area to area (illustrated in the following examples from different villages).

Specific points concerning the availability of the materials for the Mamprusi mud silo:

- *the majority of the villagers stated that the mud was easily available.*
- *it was stated in village 12 that the special grass can only be found at a far distance from the village.*
- *the grass for mixing with the mud is only available at the end of the dry season (village 13).*
- *the seeds from the Vitso tree are difficult to obtain (village 10).*
- *the clay, grass (vuyahu) and the herb (bubii) are all easily found although labour is required to 'dig out' the materials (village 14).*

Despite the low scoring for availability of materials, few farmers specified that problems existed. Generally, grass and sorghum stalks (used for thatching and production of Zana matting for the walls of the Kambong and floor of the Linga stores), and to a lesser extent wooden poles appeared to be readily available in most of the villages. The only areas where there appeared to be problems in obtaining these materials was around the Tamale area (shortages mentioned in villages 1, 3, 4 and 5), which is presumably due to population pressures since this is the most heavily populated area throughout the three northern regions. It was in this district that construction of mud silos were less affected by the availability of materials, corroborating the decision made by the MoFA to introduce the Mamprusis mud silo around the Tamale area. The only other mention of shortages of materials for the non-mud structures was by farmers in village 6, where bush fires were blamed for a lack of building materials.

Whilst the majority of people interviewed were enthusiastic about the mud silo, especially the Mamprusi design, there was one village (village 7) where one of the two groups interviewed were less keen on the mud silo:

Despite having used a design of mud silo similar to that of the Mamprusi for many years, one of the groups interviewed stated that they did not like the mud silo because:

- it is difficult to construct;
- required trained personnel (who need to be paid). The number of trained people appears to be falling;
- difficult to obtain the materials, especially the termite soil since most termite hills have been removed from the area;
- termite attack is a big problem;
- mould grows on the walls.

They would like to use a cemented design but cannot afford the high cost.

Comments

The village consisted of Kukomba tribes people who were not represented in any other of the villages visited during the survey. Since the tribal conflicts, Kukomba have been restricted to a relatively small part of northern Ghana and so this village is only representative of a small proportion of the population. In addition to this, the Kukomba are situated immediately on the border with Togo and so the village is not necessarily typical of the rest of northern Ghana.

Difficulty of construction is offset by the (generally) long life of the store. The lack of trained personnel is being addressed by the MoFA in its extension programme. Lack of termite soil is a real problem and so attempts must be made to look into the possibilities of using alternative soil types. The inconsistency of the types of soil used throughout the three regions suggests a need to quantify those factors required from a soil for the successful construction of mud silos. The problem with termites is not unique to this village and so will be addressed by the project. Similarly, moulds, which are an indication of high moisture contents/high humidities within the store, will also be investigated.

Poor availability of materials, as increasing populations place greater pressure on the local environment, is often quoted as being one of the major problems in developing countries (for example, Tyler and Harding, 1995). The ranking of availability of materials as the ninth most important factor, is a primary indication of the low population densities in the northern regions of Ghana. It is only around the main centres of population, principally Tamale, where the lack of materials becomes significant.

Ease of construction

The main problems with the Mamprusi silo appear to be the difficulty of construction, poor availability of materials, high cost, and difficulty of use. Ease of construction was not concerned with the availability of materials but considered the requirements for skilled personnel and whether they needed to be employed. The Linga store was the easiest to construct, followed by the Baare mud silo, the Kambong and the Kunchun stores, whilst the Mamprusi silo was scored as being marginally more difficult to construct than the Kunchun store. Further discussions with the interviewees indicated that the lack of craftsmen skilled in the construction of the Mamprusi silos would be, and has been, one of the main factor limiting its introduction. This was confirmed in villages 1, 2, 4 and 5, where the Mamprusi silo had been introduced but, with the exception of village 4, nobody in the villages knew how to construct this type of store. In the case of village 4, the son of the Chief had learnt how to construct the store and had built one after the MoFA had introduced the design to the village. However, he then left the village to go to school and has since been unable to build more silos. Continued extension by the MoFA should help to overcome this problem.

Acceptability

Acceptability with regard to local traditions/customs was only scored in four of the villages. Results indicated that the Mamprusi silo was the most acceptable design of structure, followed by the Kambong, Baare, Kunchun and, finally, the Linga stores. The high score obtained by the Mamprusi silo indicates that most people would very much like to try the new type of store - nobody stated that would not be interested in trying the store. Although it is not clear why the traditional stores were regarded less favourably, it is suspected that this reflects firstly, the low degree of satisfaction with these designs and, secondly, the high esteem placed by villagers on the Mamprusi design.

Cheapness of the store

Although cost was only ranked as the 12th most important factor to consider when selecting a store, cost plays a very important role since excessive costs will usually over-rule all other factors. Whilst this is particularly true in the poorer areas (UER and eastern NR) where any cost incurred will usually prevent that particular structure from being constructed, cost is also important in the other areas. Its low ranking is probably due to the use of traditional structures which can either be constructed by members of the household, or by masons who are paid in-kind. The trend towards payments in cash (for masons), and the potential introduction of a store requiring payment, will undoubtedly make cost a more important issue.

The cost of a particular type of structure is difficult to determine since it will vary from one farmer to the next depending on, for example, the levels of expertise within the family group. The cost charged by, for example a mason, may vary considerably from one client to another.

Case Study with Abdul Razeku from Jerigu village near Tamale. Abdul is the son of the Chief and was trained in the construction of the Mamprusi silo by MoFA:
Abdul would be flexible on the price of a silo depending on who he was to build for. Culturally the costs can vary considerably: • *if constructing for a friend,* • *if constructing for somebody they respect (village elder for example),* • *if constructing for a member of the family (no charge but expected to provide the materials),* • *if the person was from another tribe (in which case the cost would be higher, unless he was a friend),* • *if the person was poor.* *Method of payment could be in cash, in kind, or a combination of the two, depending on negotiations. Could also be for barter where a favour is being returned.* *Abdul stated that the reasons for the limited adoption rates for the Mamprusi silos (village 5) are due to:* • *the new design therefore unknown entity;* • *he has not yet proved that he is a 'Master builder' - still needs to build a large mud silo;* • *the cost of the silo.*

The method of payment will also vary. Traditionally, payment is in the form of goods and/or services rather than cash. However, payments are now more often being requested in cash.

Case study from village 20
Four people are employed to construct the store, one of whom will be a mason. The mason will be paid one fowl to start, food during the construction period, a second fowl at the end of construction, a large celebratory meal and a small gift (such as a bowl of tobacco).

With the exception of the Linga store, both types of mud silos were similar in cost to the other-types of traditional structure. The Linga store was classed as the cheapest to construct, followed by the Kambong type, the Mamprusi mud silo, Baare mud silo and finally, the Kunchun store. Although it was of no surprise that the Linga store was the cheapest to construct, it was interesting to note that, whilst the Kambong was marginally cheaper than the mud silo, the Kunchun store was more expensive. However, scores do not take into account the life of the store. The high scoring of the two mud silos for store life when compared to the Kambong, Linga and Kunchun stores clearly indicates that the cost of the mud silos per year of useful life is less than the other traditional types of store. This will not remove the problem of the farmer having to find the initial capital, but it is an argument for the extended use of the Mamprusi store, and should be emphasised during extension work.

The higher cost of construction of the Mamprusi store is primarily concerned with the need for trained personnel. Although trained weavers are required for the construction of the Kambong and Kunchun stores, it is far more likely that they would be found within the family, thus minimising the need to employ staff. However, the level of skill of the masons, and their scarcity, required to construct the Mamprusi store would mean that it is almost inevitable that at least one craftsman would have to be employed - hence the higher cost of construction. Costs are sometimes offset by trading tasks e.g. working in the fields farmed by the masons to pay for the construction of the stores (village 11). Although this could be seen as a real (potential) constraint to the present adoption of the Mamprusi silo, continued extension of this type of store by the MoFA will increase the proportion of the population capable of building such stores, thereby helping to overcome the problem.

As discussed in Chapter 3, cost appears to be more of a constraint in the eastern areas than in the west, especially in those localities affected by the conflicts during 1994 where the major agricultural problems stem from loss in resources (such as draught animals and cultivation equipment) and their inability to afford replacements. As an example, it was suggested in village 14 (UWR) that concreting the Vuri (mud silo), especially the base, would provide excellent protection against termites. Villagers estimated that this would take approximately 2 bags of cement (costing 24,000 cedis) and they claimed that 40% of them would be able to afford this. By comparison, farmers in villages 7, 19, 20, 21 (eastern NR and UER) all stated that they would like to use cement on their storage structures but none of them could afford it.

Interestingly, in a comparison between the Ashanti crib, Ewe barn, northern basket (presumably the Kunchun), northern mud bin (unclear as to the exact design), improved crib and sacks in the house, Tyler and Harding (1995) concluded that the mud bin was the cheapest, fractionally cheaper than the basket. They calculated that with 4,000 cedis worth of grain, the break-even costs (at 10% interest rates) for the mud bin were 4,704 cedis, compared to 4,775 cedis for the basket. These figures were far less than the costs for the other structures. Unfortunately, these authors did not include the Kambong or Linga structures in their comparison, nor did they mention the storage period involved.

Ease of use

Both types of mud silo were reported to be more difficult to use than the other types of store. The Linga store was easiest, followed by the Kunchun, Kambong, Baare and the Mamprusi types. Examination of the structures along with discussions verified these findings when it was indicated that the deciding factor for the ease of use was the accessibility of the commodity. The Linga store is easiest to extract food from, followed by the Kunchun and the Kambong stores. The problem with the mud silos is that the opening is at the top which is often difficult to reach, especially when thatched, hence the poorest score (which accounts for the high score for protection against theft). Villagers reduce this problem by only accessing the stores occasionally - say once a week when sufficient food for that week is extracted. This food is then stored temporarily, usually by the women, in clay pots or jute sacks inside the home. This practice of infrequent removal of food from the main stores tends to be the same for all types of store (e.g. village 8) in order to reduce the risk of damage to the structure (this is especially true with the Kambong store when the person, usually a child, has to climb over the wall into the store). Despite the problems of ease of access, very few villagers had constructed ladders, especially for placing inside the larger structures (village 21). Three villages (5, 10, 14) requested that additional access holes be cut in the side of the stores to improve the ease of use. However, the need for openings appears to be related to the shape of the structure - the Buri (village 11) is square and has good access from the top (therefore does not require side openings), but the Bugu is round and does require an opening.

Maintenance

Although maintenance was only discussed in one of the villages, most farmers who used mud silos mentioned the need to maintain them, especially during and after the rainy season. This conforms with the author's experience of mud silos constructed at the MoFA offices and at SARI - the former were destroyed in one season because nobody was responsible for their upkeep, whilst all of the latter survived the recent wet season because of preventative maintenance being applied as required.

CONCLUSIONS

All the farmers interviewed used storage structures, each farmer often using several different designs for different crops or storage periods. Overall, in deciding which type of structure to use, farmers were particularly concerned about minimising damage to stored grains and legumes caused by insect, termite and rodent attack. In certain areas there were particular storage problems, for example termite damage to structures as well as to the grain was a problem especially in UER. Similarly, drying difficulties and high moisture content of stored produce also caused problems in some villages, possibly leading to the production of moulds during storage.

Of the many types of storage structure found during the survey, 16 basic designs were identified, five of which were mud structures. Of these 16 designs, five of the most common types were selected for detailed comparison - the Mamprusi mud silo (as being extended by the MoFA), the Baare mud silo (widely used in the UE and UW Regions), and the Kambong, Linga and Kunchun designs found throughout the three regions.

Of all the stores, the Mamprusi mud silo was the least widely used. However, farmers who were using it, had seen it, or who had heard about its use, were impressed, and gave it high scores in terms of technical effectiveness (i.e. protection against insects, termites, rodents, water, and fire). The more widely used Baare mud silo was given lower scores on average in terms of effectiveness by those farmers who had experience of it. Both types of mud silo scored considerably higher than the other three non-mud structures. The fact that the Mamprusi design was liked by so many farmers should assist the MoFA in their attempts to introduce this structure in certain areas within the NR.

The field work suggests that the main constraints to the adoption of small mud silos, similar to, or of, the Mamprusi design, in areas where non-mud structures are in use will be cost, difficulty of construction and, in certain areas, non or poor availability of materials. Although the silo was also not felt to be particularly easy to use (nor were several of the other designs), ease of use was not felt by farmers to be a particularly important criterion for adoption. Cost and ease of construction are both linked to the availability of trained personnel which will be addressed as the use of the silos is extended by the MoFA. Research activities within the silo project into the suitability of different types of soil for the Mamprusi silo (currently termite soil and grass is recommended), will address the problem of poor availability of materials.

On balance, the prognosis for the adoption of small mud silos, such as those of the Mamprusi design, in the Western Dagbon area appears to be favourable, however, a number of issues will need to be addressed to enhance its uptake. In areas where non-mud silos are used, interventions could usefully focus on improving existing mud structures using the results from trials on the Mamprusi silo. An example of this would be the treatment of mud structures to protect against termite attack - whilst such trials will use the Mamprusi design mud silos, results will be transferable to other mud structures.[16]

RECOMMENDATIONS

1. An important technical issue for the Western Dagbon (and also those parts of UER where the Mamprusi silo is currently in use) will be the effectiveness of different types of soil and additives in the mud. It is therefore **recommended** that more detailed investigations into the availability of potentially useful construction soils (including termite soils) be undertaken. These investigations will need to build on (*inter alia*) the results of trials on soils collected during the survey.

2. The field survey confirmed that termite attack was an issue in some areas. Whilst moisture content problems were not found to be widespread in the current study, it is clear that such a problem is not obvious and can easily be overlooked. It is therefore **recommended** that the project addresses termite attack as planned in the project memorandum, and that moisture problems should also be examined in field trials.

3. Improvements in the construction of non-Mamprusi mud stores are possible. It is therefore **recommended** that efforts be made to transfer results from trials on Mamprusi silos to these other designs which are used widely in the far western parts of NR and in UWR.

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16 It was noted during the fieldwork that whilst transfer of ideas or good/bad points from one traditional design to another is almost non-existent, resulting in a stagnation of development, farmers can be receptive to new ideas brought in from the outside, as demonstrated by the general enthusiasm that has been shown towards the Mamprusi silo around Tamale.

Chapter 6
STORAGE AND MARKETING OF LEGUMES

The objectives of the legume component of this survey were to identify the methods of on-farm storage used for grain legumes (to complement the information obtained on trader storage by Golob *et al.*, 1996). The varieties of legumes grown and stored by farmers were identified, and their growing and storage characteristics assessed. Finally, the survey was to determine the typical storage life of legumes, together with the reasons for early sale.

IDENTIFICATION OF STORAGE AND MARKETING PRACTICES

Information regarding the storage and marketing of cowpeas and bambara nuts was collected from 20 villages in northern Ghana (Northern, Upper East and Upper West Regions). Both men and women farmers were found to grow and store legumes - where women had access to their own farms they tended to concentrate on growing legumes (and vegetables).

Women predominate at the lower levels of the marketing system and are as equally represented as men at higher levels (Golob *et al.*, 1996). With the exception of two villages (Zakari Yili, NR and Bamahau, UWR), marketing was carried out exclusively by women in the three regions visited. The gender division is linked to different household responsibilities of men and women. Men are primarily responsible for the production of basic staple crops for the whole compound while women are required to produce "stew" for her husband and children. Women also need to buy condiments for cooking which links them more directly into the cash economy (Golob *et al.*, 1996).

Gender divisions also have an impact on the commodities traded by the household. The marketing of staple crops grown by men is only possible in areas where a surplus is grown. Women, where they have their own farms, grow predominantly cash crops such as groundnuts, cowpeas, rice and soya bean (Golob *et al.*, 1996).

Storage structures

The type of structure used to store cowpeas or bambara was dependent on the yield, intended use and whether the legumes were to be stored unthreshed or not. Clay pots were the most popular choice of structure in which farmers stored threshed cowpea and bambara nuts. Other structures included jute sacks, calabashes (gourd), small mud silos, metal oil drums and baskets coated with cowdung and wood ash - the actual structure used will depend on the quantity of produce to be stored. Unthreshed produce was normally stored in larger structures such as the Kambong, Kunchun and Linga stores. Cowpeas and bambara nuts, kept exclusively for seed, were stored in either hand-made clay pots, small metal cooking pots, or calabashes.

Storage protection

Storage protection is essential to avoid high (or total) losses of cowpea and bambara groundnut. Problems with high losses due to insect damage were found in a number of villages, especially those in UER. Other villages, however, appeared to have addressed the problem (either with partial or total success) by the application of appropriate pest control treatments.

Examples of ineffective pest control

Bambara cannot be stored (village 3).

Insect losses are high (expect to lose 50% during storage). Insect damage is the primary reason for early sale (village 7).

Without protection, losses of 50 to 100% will occur after 3 months. Constraints to the storage of legumes are insect losses and early sale to pay off debts (village 11).

Without protection, bambara (and cowpeas) will be lost through infestation within a month. With protection (ash), storage periods of around 7 months are possible (village 12).

Storage of legumes is not very good (village 14).

Can lose 50% after 3 months, or 100% after 9 months (village 15).

Thorough drying and treatment against pests is required or else the high losses will occur. They never store unthreshed bambara due to insect damage (do not use any form of protection) (village 19).

Without regular inspection, the entire stock can be lost (village 20).

Need to keep checking bambara for infestation (village 21).

Examples of effective pest control

Cowpeas can be stored for 5 to 6 months provided the crop is treated (village 3).

Insect damage is a problem (expect to lose 25% after 4 months) but overcome, to some extent, by the use plant protectants. Primary reason for early sale is need for funds (village 6).

Plant materials are effective at reducing insect damage (village 8).

Storage for up to 8 months provided ash is used (village 10).

Bambara will store well (>6 months) provided that it is not infested from the field (village 13)

Usually store cowpeas and bambara for 3 to 6 months but if there are no financial problems, could store for 2 years (with ash) (village 15).

Bambara, if well dried and treated with lodel and pepper, can be stored for up to eight months without any problems (village 17).

Cowpeas stored in ash can be stored longer than all other commodities (village 18).

It appears that, if the storage protectant was correctly applied, and the stored crop checked at regular intervals, cowpea or bambara could be stored indefinitely without suffering significant damage. These findings confirm those of Gudrups *et al.* (1995) that where adequate pest control measures are employed, reasonable protection of crops is obtainable for short to medium term storage at farm level. Golob *et al.* (1996) suggest that on-farm storage is less successful, and the extent of damage caused by insects forces immediate sale. The villagers interviewed during the Golob survey were located mainly in the eastern NR and UER areas. These findings conflict with those obtained in the same regions during the present survey - farmers took no precautions to prevent pest damage during storage, other than to dry the commodity in the sun prior to storage.

The application of ash (including the roasting of the beans before storing in ash) was the most commonly used method of protecting stored pulses against insect damage. Other popular methods of protection included application of shea nut oil residue, chilli pepper, sand, numerous plant protectants and chemicals insecticides. Bambara groundnuts were often wetted before storage either by being left in the field until it had rained or stored outside in sacks (see chapter 5).

Cowpea varieties

Whilst farmers in all of the villages grew one or more local variety of cowpea, only in four of the villages were grown improved varieties introduced by MoFA or NGO staff (Table 12). The new improved varieties are higher yielding (under optimal environmental conditions) and fetch a better price at market than local varieties. They are usually white with a black-eye (hilium) and considerably larger than the traditional varieties. However, the main constraint found to the cultivation of new varieties of cowpea was the amount of chemical insecticides required for cultivating the crop to attain increased yields. Availability of improved seed was also a problem; several villages were willing to plant new varieties but they had no access to improved seed. Furthermore, poor resistance to damage by storage insect pests meant that all "improved" varieties are sold at harvest and none are stored (Table 12).

Local varieties, in general, have greater resistance to field pests and diseases than the improved varieties. They are also more tolerant to adverse climatic conditions and poor soil fertility. However, variations in resistant characteristics were also found among the local varieties. For example, farmers in Mandari (NR) grew two local cowpea varieties: a white "Cripple bean", and; a brown/black variety, "Demodow". The brown/black variety was grown because it was more resistant to insect pests in the field and stores. The white variety, however, suffered heavy losses in the field and during storage, but was still grown because it cooks faster, tastes better and fetches a higher price at market. Another reason for growing more than one variety was the length of maturation. For example, farmers from the village of Naafaa (NR) grew two cowpea varieties, a white short maturing variety, "Benbla", and a black, longer maturing variety, "Bensola". The black variety is planted early in April and harvested in July, whilst the white variety is planted in May and harvested in October. Staggering the harvest of cowpeas helps with labour constraints at planting and harvesting and can provide food before the main harvest of staple crops in October.

Table 12 Storage characteristics of cowpea varieties in northern Ghana.

Village No.	Village	Cowpea varieties	Length of storage	Limiting factors to storage
Northern Region:				
1	Zakari Yili	*Local variety* *Improved*	5-6 months (seed and consumption) Sold at harvest	Storage losses - only protect produce kept for seed
2	Tunayile	No data		
3	Datoyli	No data		
4	Duuyin	*Local variety* *Improved*	6 months (seed) Sold at harvest	Low cowpea yields
5	Jerigu	No data		
6	Bagbani	*Local varieties:* Tuyu (white) Sanzi (red) planted twice	6 months (seed, consumption and sale) Early harvest -eaten immediately. Second harvest - kept for seed	Storage losses and early sale
7	Gbenja	*Local variety:* Sangi *Improved:* Black-eye & brown-eye	Sold and consumed (seed?) Sold at harvest	Storage losses force early sale. Loose 100% of untreated cowpea after 6 months.
8	Bumboazio	*Local variety:* Nandon bayer *Improved (?):* Big cowpea	2-3 months and 12+ months (seed, consumption and sale)	Storage losses
9	Yipala	*Local varieties:* Biensabla (black), Bienpela (white), Bienzea (red) and Demodow (brown)	All stored for 6-7 months (seed, consumption and sale). No storage differences among varieties.	Low acreage due to financial constraints. Early sale
10	Mandari	*Local varieties:* White and Demodow (Brown/black)	Both stored 7 months (seed) Black/brown variety stores best.	Storage losses, early sale to pay debts
11	Naafaa	*Local varieties:* Benbla (white) Bensola (black)	Both stored up to 9 months (seed, consumption and sale). Black stores best	Low yield, insufficient storage facilities, early sale
12	Achubunyor (Gonja and Dagati tribes interviewed)	*Gonja:* Black and white *Dagati:* Brown and black	*Gonja:* 2-3 months (consumption and sale) *Dagati:* 8-10 months (seed, consumption and sale)	*Gonja:* storage losses *Dagati:* early sale, production costs
Upper West Region:				
13	Bulenga	*Local varieties:* Red, white and black	All stored up to a year (seed, sale and consumption). Black stores best	Production costs (low yield), early sale
14	Nabolo	*Local only*	Stored for seed	Storage losses (chemical shop shut down)
15	Jumo	*Local* only	3-6 months but could store up to 2 years	Early sale
16	Silbelle	*Local varieties:* White and brown	Seed, consumption and sale	Early sale
17	Brutu	*Local varieties:* White and black		
18	Bamahau	*Local variety*	Seed and consumption only	Low yields
Upper East Region:				
19	Bongo-Soe	*Local variety*	Seed	
20	Piaga-Chiok	*Local varieties:* Turi Kpabong and white *Improved ?:* Black	6 months (seed, consumption and sale). Do not store white and black varieties.	No problems recorded
21	Nangalikinia	*Local varieties:* Sunzuna (black), Sopupra (black with white stripes) and Sopona (white)	All stored more than 7 months (seed, consumption and sale). Sell improved variety at harvest.	Production costs (low yields)
22	Booya	*Local varieties:* White, black and white	6 months (seed, consumption and sale)	Production costs (low yields)
23	Pialoko Pusiga	*Local variety:* White	6 months	Low acreage

Storage

Only local cowpea varieties were stored; improved varieties were always sold due to high storage losses and higher market prices. Local cowpea varieties were always stored for seed for planting the following year. Storage for consumption and sale at a later date was not always possible. There appeared to be a number of factors preventing the storage of cowpea in northern Ghana: low yields as a result small cultivated areas or labour costs (especially for women's farms); early sale to release funds for clothing, medical and household expenses, school fees, etc.; excessive insect damage; and insufficient storage facilities (Table 12). The relative importance of these factors is difficult to assess as ranking exercises were not undertaken.

Cowpeas were stored for family consumption and sale in at least eight of the villages visited (Zakari Yili, Bagbani, Yipala, Naafaa, Achubumyor (all in NR), Bulenga, Jumo (both in UWR) and Nangalikinia in UER). Any reduction in the duration of storage in these villages was mainly due to early sale to meet financial needs. Low hectarage, and low yields, was also cited in five of the villages to be another important constraint to storage (Yipala, Naafaa, Achubumyor, Bulenga and Nangalikinia). Storage, therefore, tended to be limited due to the small quantities available. None of these villages experienced heavy losses due to insect pests. However, in four villages (Duuyin, Gbenja, Mandari (all in NR) and Nabolo in UWR) cowpea was only stored for seed: three of these villages did not store for consumption or sale due to excessive storage losses (Gbenja, Mandari and Nabolo), one of which also mentioned early sale to meet financial needs (Mandari). In the remaining village (Duuyin), the crop was not stored because of low yields. The findings were incomplete from the remaining villages.

Previous studies in northern Ghana have identified insect damage (Golob *et al.*, 1996) and financial needs (Gudrups *et al*, 1995) to be the major constraints to the storage of cowpea and bambara at village level. The data gathered during the latest survey suggest financial constraints played a larger role than insect damage in those villages able to use some form of storage protection.

Marketing

Market prices of cowpea varieties were obtained wherever possible (Table 13). The price can increase to over 200% from harvest to planting time. This can amount to an increase of approximately 60,000 cedis per bag of cowpeas (40 bowls) if farmers are able to store until the next planting season. The reasons to store are therefore strong but as previously mentioned, several constraints prevent farmers storing cowpeas for as long as they would wish.

Table 13 Market prices of cowpea varieties in northern Ghana.

Village No.	Village	Cowpea variety	Prices (cedis per bowl*) Harvest	3 months	6 months	Planting
8	Bumboazio, NR	Local	750†			1,500 to 2,000
9	Achubumyor, NR	Gonja tribe Dagati tribe	1,700 1,600			 1,800
10	Yipala, NR	Local	1,600			2,000 to 3,000
11	Mandari, NR	Black/brown White	600 1,000			2,000 (variety unspecified)
12	Naafaa, NR	White Black	? ?			2,000 1,600
13	Bulenga, UWR	Local	?			2,000
14	Nabolo, UWR	Local (black variety)	2,000			3,000
15	Jumo, UWR	Local	2,400			3,000
16	Silbelle, UWR	Local	1,600			3,000
21	Bongo-soe, UER	?	1,400	?	2,600††	2,400 to 2,600
22	Booya, UER	Local	1,000‡	1,500	1,800	2,400
23	Pialoko Pusiga, UER	Local	600	1,200	1,600	2,000

* 1 bowl = 4.5 kg
† 40 bowls = 1 bag
†† 5 months rather than 6 months
‡ 35 bowls = 1 bag

Cowpeas were either taken to market or, the market traders would visit the village to buy produce depending on the village's distance from the local market. If the villages were situated within a reasonable walking distance from the local market, the women were able to carry their produce on their heads to market, but traders were also willing to travel to the village to buy goods. The village of Bamahau is a good example of such a situation: it is only 5 to 6 km from the regional market of Wa (UWR). Farmers took their produce to market if they urgently required money but if they did not they waited for the traders to visit the village. Interestingly, this was the only village noted where men played a role in the marketing of commodities. They used bicycles to transport the produce to market quickly and often helped the women sell. If the commodities did not have to be sold so urgently, then the women, who did not own bicycles, would carry it on their heads. Those women living further from the market, such as in Bulenga (UER), had to rely on trucks to take them the 36 km to market. Transport costs were around 1,000 cedis per bag of produce on top of their own fare of 800 cedis. The women had little choice but to travel into the market as the traders were reluctant to travel to the villages because of the cost and distance involved. The women, however, often obtained poor prices at market because traders knew the women could not afford return home with their produce in a truck. The women of this village also complained of the Wa traders chasing away outside traders from the north and south. The outside traders paid better prices for the legumes but were prevented from buying produce at the market and at the village.

Case study of an IFAD assisted woman's group from Kokore, Bawku West in UER.

Farm sizes range from 1 to 4 acres (before the availability of loans, farms ranged from ¼ to 1 acre) Millet, maize, cowpeas, bambara, groundnuts, soya bean, okra, tomatoes and leaf vegetables are grown. Their main cash crops are groundnuts, cowpea, soya bean and bambara.

Storage protection:

Groundnut:	*Dry for 7-10 days, winnow and store in jute sacks.*
Bambara:	*Dry 7-10 days, thresh, boil for 1 minute in water with leaves of kim-kim and re-dry. Mix with ash, store in large pots or jute sacks.*
Cowpeas:	*Toast lightly with ash until beans are hot, remove and store in jute sacks.*
Soya beans:	*Mix with ash or store without any treatment in jute sacks.*

Marketing:

Commodity	Quantity harvested	Sale at harvest	Price at harvest	Price at planting
Cowpea*	1 to 3 bowls	0	1000 cedis/bowl	2,400 cedis/bowl
Bambara	1 to 6 bowls	0	700 cedis/bowl	1,800 cedis/bowl
Groundnut	5 to 10 bags	0	10,000 cedis/bag	23,000 cedis/bag
Soya	10 to 20 bowls	1 to 3 bowls	800 cedis/bowl	?

** intercropping of cowpeas, combined with the drought, have caused low yields*

Bambara groundnut varieties

Bambara groundnut is an indigenous legume grown primarily by subsistence farmers in semi-arid regions of Africa (Brough and Azam-Ali, 1992). Its tolerance to drought, and poor soils, combined with its resistance to pests and disease make it ideally suited to production in marginal areas (Harris and Azam-Ali, 1993). Although widely cultivated, bambara is an under-utilised crop and, as such, no improved varieties have been developed (Azam-Ali, 1992).

At least one or more local varieties of bambara were grown in all the villages visited during the survey (Table 14). Variations in the production, storage, and processing characteristics were observed among the varieties. For example, two varieties of bambara were grown in the village of Naafaa (NR): a white variety (sinjiblebla), and; a red variety (sinjblejie). The white variety was more susceptible to insect storage pests but it was said to taste better and cook considerably faster than the more resistant red variety. The farmers could also obtain a higher price at market for the white variety: prices of 3000 cedis/bowl could be obtained at the local market at planting time for the white variety compared with 2000 cedis/bowl for the red variety. As with the cowpea, different varieties of bambara were also grown because of their different planting dates and maturation periods. Farmers from the village of Bulenga (UWR) grew two bambara varieties: a short maturing variety (three months) and a long maturing variety (four to five months). The long maturing variety was planted in May/June and harvested in September/October, and the shorter maturing variety was planted later in July/August and harvested in October/November.

Table 14 Storage characteristics of bambara varieties in northern Ghana.

Village No.	Village	Bambara varieties	Length of storage	Limiting factors to storage
Northern Region:				
1	Zakari Yili	Local variety	6 months (seed)	Storage losses - only protect produce kept for seed
2	Tunayile			
3	Datoyli			
4	Duuyin	Local variety		No storage losses
5	Jerigu			
6	Bagbani	White, red and black	All varieties stored at least 4 months (seed, consumption and sale)	Storage losses (expect to loose 25% in bambara) and early sale
7	Gbenja	White (large) and red (small)	6 months (seed) Red variety stores better	Storage losses force early sale. Loose 50% of bambara cowpea after 6 months.
8	Bumboazio	Local variety	8 months (seed and consumption) and 12+ months	
9	Yipala	Red, black and white)	All stored for 7-8 months (seed, consumption and sale)	Low acreage due to financial constraints. Early sale
10	Mandari	White (black-eye), red/white and brown	All stored for 7 months Brown stores best	Storage losses, early sale to pay debts
11	Naafaa	Sinjiblejie (red) and Sinjiblebla (white)	Both stored for up to 9 months (seed, consumption and sale). Red stores best	Low yield, insufficient storage facilities, early sale
12	Achubumyor (Gonja and Dagati tribes interviewed)	*Dagati:* Large and small -	Both stored up to 8 months (seed, consumption and sale). Large stores best	*Gonja:* storage losses *Dagati:* early sale, production costs
Upper West Region:				
13	Bulenga	Large, small (3 months) and small (4-5 months)	Stored for more than 6 months (seed and sale only)	Production costs (low yield), early sale
14	Nabolo	Local only	Stored for seed	Storage losses (chemical shop shut down)
15	Jumo	Local only	3-6 months but could store up to 2 years	Early sale
16	Silbelle	Local only	Seed, consumption and sale	Early sale
17	Brutu			
18	Bamahuu	Local variety	Seed and consumption only	Low yields
Upper East Region:				
19	Bongo-Soe	Local variety	6-7 months (seed), up to 2 months (consumption and sale)	Low yields (bambara)
20	Piaga-Chiok	Sumpelik (white) and Sum-mong (Brown)	6 months (seed, consumption and sale)	No problems recorded
21	Nangalikinia	Sipona (white), Sizona (black), Sisinga (red) and Wiiruyi (long, white with black stripes)	Only store Sipona and Wiiruyi for approx. 6 months (seed, consumption and sale).	Production costs (low yields)
22	Booya	Sungnenga	6 months (seed, consumption and sale)	Production costs (low yields)
23	Pialoko Pusiga	Mixed colours and Bimbega (black with some white)	5-6 months (seed, consumption and sale)	Low acreage

Storage and marketing

Bambara prices increased by as much as 180% between the period of harvest and the next planting season (Table 15). Unfortunately, the storage of bambara was too often limited by the same factors preventing the long term storage of cowpeas. Low acreage's, low yields, financial constraints forcing early sale, and insect damage were all described as affecting the potential storage of bambara. These factors have been discussed previously in relation to the constraints to the storage of cowpea.

Table 15 Market prices of bambara varieties in northern Ghana

Village No.	Village	Barbara variety	Prices (cedis per bowl*) Harvest	3 months	6 months	Planting
9	Achubumyor	(Gonja tribe only)	?			2,500
10	Yipala	Local	800			2,000
11	Mandari	Local	1,000			1,600
12	Naafaa	White Red	? ?			3,000 2,000
14	Nabolo	Local	1,500			3,000
16	Silbelle	Local	1,600			3,000
19	Piaga-Chiok	Local	1,000	1,200	1,800††	2,000
20	Nangalikinia	Local	200†	500	667	667
21	Bongo-Soe	?	1,500	2,000	2,600††	2,800 to 3,000
22	Booya	Local	700‡	1,000	1,500	1,800
23	Pialoko Pusiga	Local	600	800	1,100 to 1,200	1,700

* 4.5 kg per bowl
† 30 bowls per maxi bag
†† 5 months rather than 6 months
‡ 32 bowls per maxi bag

CONCLUSIONS

Storage

Traditional varieties of cowpea and bambara were cultivated by men and women in all of the villages visited during the survey. Harvested produce was utilised for seed, family consumption and sale if yields and finance permitted. Due to the small quantities stored, the most common storage structure used for threshed legumes was the fired clay pot. Legumes were also stored in jute sacks (where the farmer could afford to purchase the sacks) and small mud silos (commonly called the Buo). Unthreshed legumes are usually stored in larger structures such as the Kambong or Linga stores.

Resistance, crop yield, and organoleptic characteristics (such as taste, appearance and cooking time) varied among the local varieties of cowpea and bambara nuts. Farmers took advantage of these variations by growing two or more complementary varieties to maximise their production for consumption and sale. Local varieties of both legumes were always stored to provide seed for next year's planting, however, storage for consumption and sale at a later date was not always possible.

Improved, higher yielding varieties of cowpea were only grown in a small number of villages - no improved varieties of bambara appeared to have been developed. When compared to improved varieties, traditional varieties were considered to be more resistant to disease and insect pests in the field and in storage. They were also more tolerant of local soils and growing conditions. Improved cowpea varieties were usually sold immediately after harvest due to their high storage losses and increased market prices.

Samples of cowpea and bambara varieties exhibiting resistance to stored-product pests were collected for future laboratory trials - samples of the resistant varieties not available at the time of the survey will be collected at a later date.

Low levels of production (a general issue affecting all crops, see chapter 3) severely limited the quantities of legumes grown, and therefore stored, by many farmers. The principal reasons for low levels of production were poor soil fertility and small acreage's due to lack of affordable cultivation equipment and high labour costs (especially for women's farms). Reasons for early sale were either to release funds for financial needs, or to avoid excessive insect damage - it was not possible to determine which of these factors predominated.

Marketing

The marketing of cowpea and bambara was almost exclusively the responsibility of the female members of the household. Women also dominated trading activities at the local level of the marketing system and were as well represented as men at higher levels (Golob *et al.*, 1996). Market prices indicated that by extending storage until later in the growing season, farmers could profit from significant increases in market prices of both commodities. Cowpea prices could increase by more than 200% between harvest and the following planting periods, compared with a maximum increase of 180% for bambara nuts.

RECOMMENDATIONS

Whilst planned project activities address the problems of insect losses during storage, production problems and the need to sell early to release funds are not currently addressed. It is therefore **recommended** that the technical outputs of the project be field tested in different financial and production environments, to assess the robustness of the project outputs.

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APPENDIX 1 Survey Design and Methodology

1. Introduction

Design and methodology of the study is determined by (a) technical and socio-economic objectives and (b) time and manpower constraints. The proposed structure attempts to resolve the potential conflicts between (a) and (b).

On the socio-economic side, a review of secondary data gives us reason to think that there are clear socio-economic differences in terms of storage behaviour which are correlated with the configuration of socio-economic cleavages. Such cleavages may take a variety of forms: wealth/class; gender; ethnicity; religion; "culture". We assume that ethnicity, religion and "culture" are correlated with geography, and that the village selection has taken this into account. Therefore, at the village level, we should be concentrating on wealth and gender.

2. Teams

There are to be two teams:

> **Team A:** Eastern Northern and Upper East: John Brice, Joyce Bediako, Sulemana Stevenson, Post-Harvest Officer (MoFA), Extension Agent (MoFA).
>
> **Team B:** Western Northern and Upper West: Caroline Moss, Neil Marsland, Richard Yeboah, Post Harvest Officer (MoFA), Extension Agent (MoFA)

3. Villages Covered and Timetable

Training villages on Monday 15/7/96, and Tuesday 16/7/96. Each team does 5 villages per region, 1 day per village, 1 week per region. Thus both teams will be in the field for approx. 2 weeks (see appendix 2 for more details).

4. Proposed Structure

(a) Modules: There will be a village level introduction followed by six basic modules per village:

- Module 1: General village level data
- Module 2: Socio-economic verification
- Module 3: Introduction to Storage Practices
- Module 4: Storage Structures
- Module 5: Storage Protection
- Module 6: Case Study

(b) Timings: It is very important that villagers are not overloaded. We need to remember that we are taking up their time at a busy period in the agricultural year. Moreover, concentration of both team members and informants will deteriorate after a while. Thus we need to focus on the key issues, make the discussions interesting and allow for breaks so that we and they can rest. The following are indicative timings to aim at:

Village Introduction:	10 minutes
Module 1:	1 hour
Module 2:	30 minutes - 1 hour
Module 3:	1 hour
Module 4:	1 hour
Module 5:	1 hour
Module 6:	2 hours

If these timings prove to be realistic, then assuming we start the day at 9am we should be finished at around 5pm, allowing some time for flexibility.

It is proposed that within each village each group divides into 2 sub-groups so that more ground can be covered.

Village Introduction

Notes: We are here to dispel ulterior motives, full and honest participation is appreciated, privileged to be here, we are students you are teachers, etc.. We would like to discuss with you about your village, some of the problems faced and potential solutions to these problems.

Module 1: General Village Level Data

Time: 1 hour
Informants: Village headman and well-respected people in the village
PRA Group Structure: 1 group, 2 questioners, 2 note takers, 1 observer
Objective: General overview of farming systems, gender divisions, socio-economic stratification.
Tools: Semi-structured interviewing ; preference ranking/scoring; direct observation.
Key Issues: Ethnicity, religion, crops grown, cropping calendar, storage structures, gender divisions in production storage and marketing; socio economic stratification and households, % of households falling into each category; socio-economic differences in storage behaviour (see appendix 1: Checklists for more details)
Methodology:

- PRA team discusses farming systems and gender divisions with Village Headman (VH) and respected community members (no more than 5 or 6) using Semi-Structured Interviewing techniques (SSI).
- Informants asked to list all the agricultural problems (production, storage and marketing related) and then to rank and score these.
- The group is then invited to select 3 or 4 households per category from the village.

Module 2: Socio-economic verification

Time: 30 minutes - 1 hour
Objectives: To determine whether selected respondents have been correctly classified.
Tools: SSI and direct observation.
Methodology: PRA team splits into 2 sub-groups. Each sub-group follows up on the suggestions from the VH and elders concerning wealth classification of individual households. We should decide how best to organise this module. One way would be to ask villagers to remain after the initial village introduction. After module 1 is completed and households have been selected, it should then be easy to locate them from the gathering. Each selected household head would then be taken to one side and interviewed briefly to find out whether he/she has been correctly classified. If so he/she is invited to join group discussions, if not a replacement is found.

Module 3: Introduction to Storage Practices

Timing: 1 hour
Informants: Purposely selected wealth category representatives.
PRA Group Structure: Each team splits into 2 sub-groups. In each group, one person asks questions and facilitates, the other writes notes. The notes should be written in English. John, Caroline and Neil will review responses at the end of each sub-section (see appendix 1). NOTE: We should, aim for mixed groups of both men and women. 3 - 4 man and wife couples. We will be able to ask questions which mainly pertain to men whilst the women are present. For those issues that are directed specifically towards women however, it may be necessary to take the ladies to one side and interview them separately.
Tools: SSI.
Objectives: To determine the crops grown, the types of structures they are stored in, types of protection used, gender responsibilities of storage.
Key Issues: What crops are grown, where are they stored, what are the main pests that attack the crops, who is responsible for growing and storage?
Methodology: Use SSI for whole module

Module 4: Storage Structures

Time: 1 hour
Informants: Purposely selected wealth category representatives.
PRA Group Structure: As for module 3. NOTE: If clear gender divisions come up re. storage under module 3, then we should tailor our questions accordingly.
Objectives: (a) Identify pros and cons of large grain storage structures: Kambong, Kunchun, mud silos. (b) Focus on cowpeas, bambara nuts and soya where applicable.
Tools: SSI, preference scoring, direct observation, sketching.

Key Issues: Current grain storage structures, scoring of different structures, extent of mud silos, reasons for use, good and bad points about silos, Kambong, Kunchun. Focus on storage structure problems of cowpeas, bambara nuts and soya where applicable.

Methodology: Use SSI for sub-sections 1 and 3 and preference scoring for sub-section 2. SSI in sub-section 3 will take the form of interviewing the diagram, using a pre-determined checklist as a guide.

Module 5: Storage Protection

Time: 1 hour

Informants: As for module 3.

PRA Group Structure: As for module 3.

Objectives: Compare and contrast current methods of storage protection, current extent of use of plant materials, potential and constraints to use, focus on bambara, cowpeas and soya where applicable.

Tools: As for module 4.

Key Issues: Current methods of pest control, factors determining the use of different methods, ranking of factors, scoring of methods, good and bad points of plant-based materials.

Methodology: As for module 4.

Module 6: Case Study

Time: 2 hours

Informant: Purposely selected individual.

PRA Group Structure: As for module 3.

Objective: To obtain an in-depth idea of the storage behaviour of one individual representing a socio-economic group not covered in modules 3, 4 and 5.

Tools: SSI, preference scoring, direct observation.

Key Issues: As detailed under modules 3, 4 and 5 above.

Methodology: As for module 4.

APPENDIX 2 CHECKLISTS AND TOOLS

VILLAGE INTRODUCTION:

Particular care to be taken to explain exactly why we are visiting the village. The objective is to learn from the villagers about their village and more especially about storage practices. They will be teaching us, therefore, we are the students and they are the teachers.

MODULE 1: GENERAL VILLAGE LEVEL DATA

Ethnicity, Religion, Customs

- Tribes and languages in the village
- Religions and customs
- Number of households in the village

Farming Systems

- Land sizes, estimate of average size of land owned, cultivated
- Crops grown in the village: food crops, cash crops, food/cash crops
- Main staple food crops, main cash crops
- Livestock ownership: types of livestock in the village

Seasonal Calendar

- Timings of land preparation, planting, weeding, harvest of the main cash and food crops including bambara and cowpea.
- Responsibilities of men and women regarding production, storage, marketing
- Agricultural problems faced during the process of production, storage, marketing
- Listing and ranking of agricultural problems

NOTE: If possible, the first three points should be combined using the spine of the seasonal calendar. Thus one sequence of questions might be: when do you prepare your land ?; who takes responsibility within the family for this ?; do you face any problems in land preparation ?

MODULE 2: STORAGE CATEGORISATION

- PRA teams write down the number of household heads or representatives of households at the gathering.
- If 15 or less, say that we want to talk to all of them on a one to one basis. If more than 15, PRA team asks each household head or representative to pick a piece of paper from a hat or container of some sort. Those with a number on: we want to talk to, those without a number on: we don't.

Categories we are looking for:

- Families who do not store (ask the reasons*)
- Families in the village who normally have staple food in store for between 1 - 3 months after harvest (ask reasons).
- Families falling into the 3 to 6 month category (with reasons)
- Families falling into the 6 to 9 month category (with reasons)
- Families falling into the 9 to 12 month category (with reasons)
- Families falling into the 12+ month category (with reasons)

* When we have taken household heads or their representatives to one side, we ask first about the length of time that they store staple food, and second probe into some reasons for the length of storage period. What are the common factors that result in a group of families only being able to store for 0-3 months for example, or 3-6 months?

- *store different staple food crops,*
- *size of harvest,*
- *size of family,*
- *types of storage structures used,*
- *different storage protection methods.*

PRA sub-teams confer and construct the groups. Group work can then begin. It was decided that the 3 -6 month and the 9 - 12 month categories should be used for the group work, and that the 1 -3 month and 6 - 9 month categories should be used for the case studies (assuming that there were sufficient numbers of prople falling into these catagories). (In the event of some groups being very small, different groups may be used for the group work/case studies).

MODULE 3: STORAGE STRUCTURES

Part A Introduction to Storage Systems

What commodities do you grow?
Who grows them (men/women)?
What commodities do you store?
How long do you store each commodity for?
Who stores them?
Who has responsibility for taking food out of the store:

- *for consumption*
- *for sale*

Part B Storage Structures

Stores currently used?

- *type*
- *capacity (volumetric)*
- *age*
- *expected life*
- *type of commodity stored in each type*

Are these stores traditional to the locality or have they been introduced?
If they have been introduced:

- wh*en?*
- *why?*
- *by what means?*
- *what was used before?*
- *are they happy with the new stores?*

Cost of stores (initial and subsequent)

- *self-build/contracted*
- *materials*
- *labour*
- *time*
- *transport (for commodities)*

BREAK FOR DISCUSSION

Part C Farmers perceived advantages/disadvantages of various store types

Scoring of different (large) structures:

- *List the types of store - suggest including the mud silo if not already considered*
- *List the factors considered when deciding on the type of store to use (if necessary, suggest one or two factors from those listed below not mentioned by the villagers)*
- *Rank the factors*
- *Score each store against each factor in turn*

	Rank	Mud silo	Kambong*	Kunchun*	*	*
Ease of construction						
Availability of materials						
Ease of use						
Protection against:						
rain/water						
insects						
rodents						
birds						
theft (security)						
Life of the store						
Acceptability (ethnic?)						
Cost of stores						
Termites						
Fungi on walls						

* Stores currently used (local name and, if necessary, a sketch and brief description)
Method of scoring:
0 Poor................10 Good

BREAK FOR DISCUSSIONS

Part D Examination of the matrix

Why certain markings?

- If a problem with insect and/or rodent infestation in silos - do they have lids on at all times?

Focus on storage structure problems of cowpeas, bambara nuts and soya where applicable.
If you had to choose one type of store, which would you choose and why?

Part E Questions specifically concerned with mud silos

If they use Mud Silos:
Why?

- *good/bad points*
- *limitations*

Type of materials

- *soil source**
- *grass type*

Availability and sustainability of suitable materials
Termite problems

If they don't use Mud Silos:
Are they aware of mud silos? Describe them

- *size,*
- *shape,*
- *internal compartments,*
- *materials used,*
- *method of construction.*

Do they wish to use them?
....if so, who would construct them?

Suggestions for modified design e.g. improved access	Local constraints e.g. availability and sustainability of materials.
Were they easily affordable?	How much would they be prepared to pay?
Would all groups within the village be able to afford them?	What would they use them for?

* Soil of specific types are often used - primarily from termite hills.

BREAK FOR DISCUSSION

MODULE 4: STORAGE PROTECTION

Part A Introduction to Storage Protection

Do the farmers protect their stored grain against insect damage?
....if they don't, do they know anyone who does?
What type of protection is used?

- *insecticides versus traditional practices*
- *inert materials/plant materials*
- *phosphine - if so, dosage, exposure period, in which structure and problems (illness, ineffective)*

Why do they use this particular type of control?

- *cost*
- *availability*
- *tradition*

Who is responsible for protection?

Part B Examination of the types of protection systems

Scoring of control methods

	Rank	Chemicals	Inerts (Ash...)	Plants	Others (Smoke...)	Phosphine
Cost						
Availability						
Ease of use						
Effectiveness						
Versatility (other uses)						
Acceptability (ethnic?)						

BREAK FOR DISCUSSION

Part C Examination of the matrix

Why certain markings?

Part D Questions specifically concerned with Plant Materials (ignore if they don't use Plant Materials)

What plant materials do they use

- *what are they (local/Latin names)?*

What crop(s) is it used to protect?

- *seed only or the whole crop?*
- *if only the seed, why not the whole crop?*

What parts or extracts of the plant are used?
How are the plant materials applied?

- *preparation of plant/plant extract*
- *how often*
- *how much is applied*

Where was it obtained from?

- *locally collected*
- *market*
- *friends & family*
- *extension officers*

How did they find out about it?

- *family & friends*
- *trader*
- *extension officer*

Would farmers prefer to use insecticides if they were affordable and readily available?
Is the plant used for any other purpose?

- *medicinal*
- *spice*
- *food*

BREAK FOR DISCUSSION

COLLECT SAMPLES AND PRESS

MODULE 5: LEGUMES

Do they call indigenous varieties 'cowpeas' and new varieties 'beans?
How do they store legumes?

- *prewetting and redrying prior to storage*

What constraints are there to storing legumes?

- *excessive losses*
- *early sale to release funds*
- *prewetting and redrying of bambara prior to storage..if yes, 'what', if no, 'why'.*

How much of the crop is lost during storage?

- *estimate of percentage loss over storage period*

What causes the losses and in what proportion?
Which varieties do they grow?

- *traditional versus introduced cultivars*
- *reasons for the different varieties*

Why do they grow these varieties?

- *home use versus sale (proportions and storage duration)*
- *taste*
- *processing*
- *disease resistance*
- *insect resistance*

How did they obtain these varieties?

- *saved seed*
- *market*
- *extension officers*

Have attempts been made in the past to introduce new varieties?
Were the new varieties adopted and, if not, why not?
Would farmers be prepared to try new varieties?
Would farmers be prepared to participate in a loss assessment survey for legumes (in particular) - farmers would be visited on a regular basis (say, once a month), when small samples would be collected (either bought or swapped).

BREAK FOR DISCUSSION

COLLECT SAMPLES (1 kg of uninfested and approx. 0.2kg of infested) OF EACH TYPE OF LEGUME (within reason)

MODULE 6: CASE STUDY

Production Systems

- Total acreage farmed
- How often is each commodity grown in one year.
- Production patterns - mono, mixed and relay
- Acreage of each commodity plus yield

Storage Systems

- Total quantity stored (by commodity and in what type of store)

Marketing Systems

- Quantities sold at harvest
- Quantities marketed each week

APPENDIX 3 Data from the assessment of the types of post harvest pest control

Table A3.1 Mean scores from the Matrix

	Rank	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plants*	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Actellic	Phosphine	DDT	Mahogany	Orange peel	Kolaa	Calcium carbite
Cost	1.8	9.1	8.2	9.7	10.0	9.0	7.0	7.0	8.0	8.5	9.0	6.7	2.5	2.8	2.6	3.0	5	2.0	8.0	2.0
Availability	2.5	8.5	8.1	10.0	6.0	4.0	4.0	6.4	7.3	7.0	7.8	7.3	5.0	2.8	2.5	1.0	7	1.0	6.5	5.0
Ease of use	3.9	8.4	7.8	9.0	10.0	3.0	8.0	6.2	5.8	8.0	7.8	5.8	6.0	4.9	4.0	1.0	7	4.0	5.0	5.0
Effectiveness	2.5	6.0	6.4	4.0	10.0	3.0	8.0	6.3	5.8	6.0	4.8	9.0	7.7	7.8	8.6	2.0	4	6.0	7.0	5.0
Acceptability	4.4	4.4	3.0		10.0	4.0	7.0	6.6	4.5	5.0	1.5	7.7	8.3	7.9	9.6			5.0	8.5	
Versatility	5.0	4.5	3.9		9.0	7.0	6.0	5.4	5.0	6.0	4.0	7.7	9.0	9.1	7.0		10	6.0	6.5	8.0
Toxicity	3.0	10	10	9.5				9.7		8.0	7.0	7.5		1.5	1.0	0.0				

* 'Plants' refers to all plants other than those specifically listed in the table (ie all plants other than Neem seeds, Neem leaves, Kim-kim, Lodel and Kul-enka).

Table A3.2 Number of the scores from the Matrix

	Rank	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plants*	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Actellic	Phosphine	DDT	Mahogany	Orange peel	Kolaa	Calcium carbite
Cost	11	11	9	3	1	1	1	6	4	2	4	3	2	9	8	1	1	1	1	1
Availability	10	11	10	2	1	1	1	5	4	1	4	3	3	9	8	1	1	1	2	1
Ease of use	11	11	9	3	1	1	1	5	4	2	4	4	3	8	7	1	1	1	2	1
Effectiveness	11	12	10	3	1	1	1	6	4	2	4	4	3	9	8	1	1	1	2	1
Acceptability	5	7	7	0	1	1	1	5	4	1	2	3	3	7	5	0	0	1	2	0
Versatility	6	8	8	0	1	1	1	5	4	1	3	3	3	7	6	0	1	1	2	1
Toxicity	3	3	1	2	0	0	0	3	0	2	2	2	0	2	3	1	0	0	0	0

Table A3.3 Standard deviation of the scores from the Matrix

	Rank	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plants*	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Actellic	Phosphine	DDT	Mahogany	Orange peel	Kolaa	Calcium carbite
Cost	0.9	2.2	2.4	0.6				3.0	2.8	2.1	1.4	1.2	2.1	2.5	2.3					
Availability	1.0	1.3	1.9	0.0				2.7	1.5		2.6	1.2	3.6	1.9	1.9				2.1	
Ease of use	0.9	1.6	3.1	1.7				3.4	3.3	2.8	2.9	4.0	1.0	3.8	2.7				4.2	
Effectiveness	1.7	2.3	3.0	2.6				1.2	1.0	2.8	3.8	1.4	3.2	2.2	2.5				1.4	
Acceptability	1.3	1.6	2.4					3.4	1.7		0.7	0.6	2.1	2.0	0.9				2.1	
Versatility	1.7	2.5	3.0					2.6	2.9		5.2	2.5	1.0	0.9	3.6				0.7	
Toxicity	1.0	0.0		0.7				0.6		2.8	0.0	3.5		0.7	1.0					

Table A3.4 Median of the scores from the Matrix

	Rank	Ash	Smoke	Sand	Shea & pepper	Shea nut	Pepper	Plants*	Neem seeds	Neem leaves	Kim-kim	Lodel	Kul-enka	Actellic	Phosphine	DDT	Mahogany	Orange peel	Kolaa	Calcium carbite
Cost	2.0	10.0	10.0	10.0	10.0	9.0	7.0	7.0	9.0	8.5	9.5	6.0	2.5	2.0	2.0	3.0	5	2.0	8.0	2.0
Availability	2.0	9.0	8.0	10.0	6.0	4.0	4.0	6.0	8.0	7.0	8.5	8.0	4.0	2.0	2.0	1.0	7.0	1.0	6.5	5.0
Ease of use	4.0	9.0	9.0	10.0	10.0	3.0	8.0	7.0	5.5	8.0	8.5	6.0	6.0	4.0	3.0	1.0	7.0	4.0	5.0	5.0
Effectiveness	2.0	6.0	7.5	5.0	10.0	3.0	8.0	6.5	5.5	6.0	5.0	9.5	9.0	8.0	10.0	2.0	4.0	6.0	7.0	5.0
Acceptability	5.0	4.0	2.0		10.0	4.0	7.0	8.0	4.5	5.0	1.5	8.0	9.0	8.0	10.0			5.0	8.5	
Versatility	6.0	4.0	2.5		9.0	7.0	6.0	6.0	5.0	6.0	1.0	8.0	9.0	9.0	8.5		10.0	6.0	6.5	8.0
Toxicity	3.0	10.0	10.0	9.5				10.0		8.0	7.0	7.[illegible]		1.5	1.0	0.0				

Table A3.5 List of Plants Collected during the survey

Plant sample	*Location collected*	*Uses*	*Description*
1. Grass	Funsi, UWR (CM)	Mixed with mud for construction of silo	Fine needle-like leaves
2. Grass "Kul-enka"	Bongo-Soe, UER (JB)	"Sorghum-like" heads (complete with panicles and seeds) mixed with all produce. Also used to treat malaria.	Similar to 1 (no flowers). Can grow to approx. 4 ft
3. Herb "Kim-kim"	Bongo-Soe, UER (JB)	Leaves boiled until water turns red. Either pour water over bambara or put nuts in water for 1-2 mins, dried and stored	Labiatae, sample approx. 40 cm in height. Can grow to approx. 4 ft
4. Shrub "Dabokuka"	Bongo-Soe, UER (JB)	Leaves dried, ground into a powder, sprinkled at base of mud silo. Prevents attack from termites to silo(?) and stored millet & sorghum. Also used to treat foot-rot in animals.	Small shrub, pinnate leaves.
5. Shrub "Lodele"	Brutu, UWR (CM)	Pound leaves, dry and mix with ash.	as above
6. Herb "Kpasiuk" (?could be 12 -newspaper)	Piaga-Chiok, UER (JB)	Mature plants mixed with produce (beans, bambara and millet) the stored. Can put black seeds in eye if you have something in it (?)	Similar to 3. but hairy
7. Herb "Dunkpoo"	Bumboazio, NR (JB)	Leaves boiled with leaves of 8. as below. Leaves can also be burnt fresh, dried on charcoal and left in room to repel mosquitoes	Same as 3.
8. Tree "Famatitabga"	Bumboazio, NR (JB)	Leaves boiled with leaves of 7. until water red then bambara (unshelled?) are added to water, removed dried and stored in jute sacks. Can also be used to treat diarrhoea.	Robust, oval leaves, approx. 10 cm long, 7 cm wide, whorls of 3 leaves
9. Herb	Gbenja, NR (JB)		Lanceolate leaves, approx. 10 cm long, 3 cm wide, whorls of three
10. Herb	Gbenja, NR (JB)		Simple leaves in whorls of three, approx. 7 cm long by 3 cm wide
11. Shrub/tree "Palga"	Bagbani, NR (JB)	Roots are crushed, dried and the powder mixed with commodity. One milk tin per bowl of seed. Alternatively a solution is prepared and sprinkled on seed. Used for storing seed only as can cause diarrhoea. Also used to treat migraines, scorpion bites, pains around the waist, hernias and abortions (1-3 months). Can be used as soap for washing clothes	Lanceolate leaves, approx. 3 cm long, 1 cm wide. Thick and slightly waxy. Same as "Poni"
12. Herb "Chia" or "Weldwa"	Nangalikinia, UER (JB)	Either whole leaves or powdered leaves added to produce (all commodities) in stores	Small seedlings, look very similar to 4.
13. Herb "Dakpezungwari" ?	Booya, UER (JB)	Leaves are boiled, removed from water, immerse bambara (unshelled?) for 1-2 minutes, dry and store	Labiatae, approx. 25 cm in height, leaves 2 cm long, oval, flowers on terminal raceme, arranged in whorls

APPENDIX 4 Data from the assessment of storage structures

Table A4.1 Mean Scores from the Matrix

	Ranking	Store types									
		A	B	C	D	E	F	G	H	I	J
Effectiveness of the Structures:											
Protection against Rain/water	3.4	9.8	6.0				6.5	2.0	4.2	8.5	4.0
Protection against Insects	1.5	9.0	5.8				4.4	4.6	4.9	7.5	1.5
Protection against Termites	2.7	7.0	4.0						1.5	8.3	5.0
Protection against Rodents	3.1	8.6	5.0				2.5	2.8	4.9	7.0	5.5
Protection against Theft (security)	4.1	8.7	10.0		3.0		3.6	3.7	3.4	5.8	1.7
Protection against Fire	5.0	10.0	9.0				3.3		2.0	10.0	3.0
Acceptability of the Structures:											
Ease of construction	3.9	5.0	6.3	6.3			6.1	8.0	5.1	6.7	0.7
Availability of materials	3.8	4.8	6.8				5.8	5.2	6.1	5.5	5.5
Ease of use	5.0	4.0	4.3				5.6	7.5	5.7	8.3	5.5
Maintenance		10.0					2.0		2.0		
Life of the store	3.6	9.6	8.4		7.0		3.4	1.3	3.0	8.3	3.3
Acceptability (ethnic?)	4.3	9.5	5.5	6.8			6.0	4.0	4.5	6.7	1.0
Cheapness of stores	4.6	4.7	4.5				5.1	7.7	3.6	6.4	4.0
No. of crops	2.5	9.2	8.0		5.0		7.6	3.0	2.0	8.0	7.5
Store capacity	3.5	6.3	10.0				7.0	7.0	1.7	3.0	2.0

where: 'A' is the Mamprusi mud silo
'B' is the Conical mud silo;
'C' is the Square/circular mud silo with narrow neck passing through the roof;
'D' is the brick built square silo;
'E' is the Buo portable mud store;
'F' is the Kambong;
'G' is the Linga (raised wooden platform);
'H' is the Kunchun;
'I' is the fired clay water pot;
'J' is the jute sack.

Table A4.2 Frequency that each type of Storage Structure was scored against the Storage Factors

	Ranking	Store types									
–		A	B	C	D	E	F	G	H	I	J
Effectiveness of the Structures:											
Protection against Rain/water	5	5	2	0	0	0	4	1	5	4	2
Protection against Insects	11	12	5	0	0	0	12	5	11	6	4
Protection against Termites	3	1	3	0	0	0	0	0	2	3	1
Protection against Rodents	11	10	2	0	0	0	9	4	9	4	2
Protection against Theft (security)	8	8	2	0	1	0	8	3	5	4	3
Protection against Fire	1	2	1	0	0	0	3	0	2	2	1
Acceptability of the Structures:											
Ease of construction	8	9	4	1	0	0	8	3	8	6	3
Availability of materials	11	11	5	0	0	0	10	5	10	6	4
Ease of use	3	4	3	0	0	0	4	2	3	3	2
Maintenance		1	0	0	0	0	1	0	1	0	0
Life of the store	8	7	5	0	1	0	6	3	7	6	4
Acceptability (ethnic?)	3	2	2	1	0	0	1	1	2	3	1
Cheapness of stores	7	6	4	0	0	0	6	3	7	5	4
No. of crops	2	5	1	0	1	0	5	1	3	2	2
Store capacity	2	3	1	0	0	0	4	2	3	1	1

Table A4.3 Standard Deviation of the Scores from the Matrix

	Ranking	Store types									
		A	B	C	D	E	F	G	H	I	J
Effectiveness of the Structures:											
Protection against Rain/water	0.9	0.4	2.8				2.4		4.0	1.9	5.7
Protection against Insects	1.5	1.4	2.4				2.4	3.9	1.9	2.0	0.6
Protection against Termites			1.7						0.7	0.6	
Protection against Rodents	1.8	3.3	4.2				1.7	2.4	3.1	4.8	6.4
Protection against Theft (security)	1.8	2.8					2.6	4.6	1.1	4.0	2.1
Protection against Fire							0.6		1.4		
Acceptability of the Structures:											
Ease of construction	2.2	4.2	2.4				2.6	3.5	3.7	3.4	0.6
Availability of materials	1.9	3.8	3.5				2.6	1.5	3.2	2.2	5.2
Ease of use	2.0	2.6	0.6				3.0	2.1	2.5	1.5	4.9
Maintenance											
Life of the store	2.1	0.8	0.5				1.6	0.6	2.2	2.0	2.1
Acceptability (ethnic?)	3.1	0.7	0.7						0.7	1.2	
Cheapness of stores	2.0	3.1	2.6				2.9	2.1	2.4	2.7	4.1
No. of crops	0.7	3.0					2.3		1.7	1.4	2.1
Store capacity	2.1	1.5					2.2	1.4	1.2		

Table A4.4 Median of the Scores

	Ranking	Store types									
		A	B	C	D	E	F	G	H	I	J
Effectiveness of the Structures:											
Protection against rain/water	3.0	10.0	6.0				5.5		5.0	9.0	4.0
Protection against insects	1.0	10.0	7.0				4.5	6.0	3.0	6.5	1.5
Termites			5.0						1.5	8.0	
Protection against rodents	3.0	10.0	5.0				2.0	2.0	4.0	9.0	5.5
Protection against theft (security)	4.0	10.0					3.5	1.0	3.0	6.0	1.0
Protection against fire							3.0		2.0		
Acceptability of the Structures:											
Ease of construction	4.0	4.0	7.0				5.5	10.0	5.5	7.0	1.0
Availability of materials	4.0	4.0	9.0				5.5	5.0	6.0	6.0	5.5
Ease of use	5.0	4.0	4.0				4.5	7.5	6.0	8.0	5.5
Maintenance											
Life of the store	3.5	10.0	8.0				3.8	1.0	2.0	9.0	3.0
Acceptability (ethnic?)	5.0	9.5	5.5				6.0		4.5	6.0	
Cheapness of stores	5.0	3.5	5.0				4.8	7.0	3.0	6.0	2.5
No. of crops	2.5	10.0					7.0		1.0	8.0	7.5
Store capacity	3.5	6.0					6.5	7.0	1.0		

Table A4.5 Life, capacity, cost, and construction details of stores discussed during the survey

Code	Store Type	Local name	Village	Life	Capacity	Cost (cedis)	Details of construction
A	Mud silo 1 (Mamprusi)	no name	5			30,000	
		Bule	2	> 30 years	8.5 bags	30,000 + 3 bags of grain	
		Lipil	7	> 40 years (up to 70 years)	20 to 25 bags	30 to 40,000	30 man days to collect materials, 2 men to build (contracted or self). Takes 14 days.
		Buga[a]	10	> 50 years			
		Buga	11	> 20 years			Work for 2 to 3 hours at three day intervals (drying times).
		Bugi[b]	11	> 20 years			As Buba
B	Mud silo 2	Bui	19	1 to 2 years (on wood) 4 to 5 years (on stone)			
		Baare or Tula	20	?	up to 15 bags	Two fowls, meals, gifts plus 4 to 8,000 for coal tar.	Built in 12 layers, one layer per day (less nearer the top). Four people for the whole period.
		Baari	21	1 to 5 years (7 years)	10 to 20 bags (10 to 12 bags)	Two Guinea fowls plus meals for 12 days	
		Bood	22	7 years+ (15 years+)	up to 5 bags	2,400 for the mason, two fowls, food each day plus a final main meal.	Three people (including trained mason) for eight to nine days during the dry season (good drying).
		Bwr	23	6 to 10 years+	20 bags	Meals for the mason, large meal at the end plus a fowl at the end.	Three people, one week.
C	Mud silo 3	Katari[c]	12	20 to 30 years	4 to 10 bags		Seven days
		Bowr[d]	12	20 to 30 years	8 to 30 bags		Two weeks
		Bowr[d]	17				
		Bawryari[d]	12	20 to 30 years	10 to 40 bags		Two weeks
		Vuri[e]					
D	Mud silo 4	Vuro	14	20 to 30 years	15 to 30 bags		One to two weeks, morning and evening each day (drying between shifts).
		Namvuri	14	10 years (< 5 years)	10 to 30 bags+		One week. Less sturdy than the Vuro.
E	Mud silo 5	Buo	13	50 years+	1 to 2 bags		Five days
		Katanga (larger Buo)	13	50 years+	6 bags		Nine days
		Bowrpla	17				
F	Wooden framed, thatched	Kambong	1	6 years			
		Kambong	2	6 to 7 years	up to 60 bags	up to 60,000	
		Kambong	4	7 to 10 years (1 year single/3 years double zana)			
		Kambong	5	3 to 4 years	10 bags		
		Kpacharaga	6	up to 5 years	40 to 50 bags		

		Kpacharaga	7	up to 3 years, (6 max)*	10 to 14 bags (20 to 40 bags)	30,000	Three people (non skilled). Twelve days to collect materials, four days to build.
		Chenchunkum	6	up to 6 years	6 bags		
		Chenchenlenkung	7	2 years (5 years)	<15 bags	2 to 3,000	Two people (un-skilled). One day.
		Napoo	8	up to 5 years (10 years)	10 to 20 bags (10 to 40 bags)	10 to 12,000	Two people (un-skilled). Eight days.
		Sigi	10	5 to 6 years 1 yr (if moved)			
		Brugu	11	1 year			
		Ganga[7]	13	1 year	1½ to 15 bags		
		Narpung	23	1 to 2 years	up to 10 bags	negligable	Main time is the collection of materials. Construction takes two to three people one day.
	Floorless, wooden framed, thatched	Sogli	6				
	Conventional hut (in the field)	Libuul	7	1 year	up to 60 bags	<10,000	
G	Raised Platform	Linga	2	up to 9 years			
		Linga	6	?	typically 6 bags		
		Linga	8	30 years	8 to 60 bags	?	
		Kikaafil	7	up to 40 years	up to 30 bags	12 to 20,000	Four men (non-skilled). Three days.
		Capala[7]	10	5 years			
H	Baskets:						
	(i) Unplastered	Kunchun	7	10 to 15 years	2 to 20 bags	12 to 20,000	One person. Two weeks.
		Kunchun	8	up to 4 years (10 years)	2 to 20 bags (10 to 20 bags)	10,000	Six people collecting material for two days. Three days.
		Chenchunkum	1	2 to 4 years, grass roof 2 years			
		Napogu	2	> 10 years			
		Napogu	4	6 years			
		Pege	11	1 year			
		Sampaa(?)	13	7 years	6 to 20 bags		
		Yikori	19		3 to 4 bags		
		Koyonko	21	2 to 5 years (7 years)	1 to 2 bags (4 bags)	20,000	
		Naparg[8]	22	1 year	10 bags+	usually zero as most people can weave	Three to four people for one day, including one who can weave.
	(ii) Plastered	Chenchunkum	1				
		Chenchunkum	2				
		Chenchunkum	3				
		Pupuri	2		10 to 50 bags	10 to 20,000	
		Pupuri	4				
		Pupuri	5				

		Kunchun (Kupong)	6	<5 years	12 bags		Two to four days to weave the matting
		Kosorgu	13	50 years+	3 bags		One day
		Kosorgu	23				
		Yikori	19				
	Temporary structure	Sinklepohingu	8	up to 5 months	1 to 2 bags	2,000	One to two hours, no skill required.
I	Fired clay pots	?	7	10 years	10 bowls		
		Singi	11	2 years (clay), many years (metal)			
		Simme	12	2 years	1 to 1½ bags		
		Dugu	13	50 years+	10 bowls		One day
		Vijen	14	40 years	1 basin		
		?	20		1½ bags (small) 3 bags (large)	5,000 (small), 10,000 (large)	
		Dokoh	21	40 years+	1 to 1½ bags (2 bags)	up to 30,000 (v.large)	
		Yor (small)	22	long time	1 to 3 gallons	700	
		Duk (large)	22	long time	up to 45 gallons	3,200	
		Duk (large)	23	10 years+	all sizes	600 to 4,000 depending on the size	
	Enclosed raised platform	Seri*	12	1 season	variable with yield		One day
		Yam barn (Pilawe)	14	1 season			
	Small hut	Napogu	6	max 20 years	40 to 50 bags		Small mud hut with raised platform, covered with Zana matting
J	Jute sacks		4				
			6	< 4 years			
			8				
			10				
			13	2 years	40 bowls		
			14	2 years			
			20			3,000 for new jute, 2,000 for old fertiliser bags	
			22	<1 year in some cases		3,200 for new jute, 1,200 for old	
			23	<1 year if attacked by rodents		> 1,600	

* where there were two groups interviewed in a village, the second groups response is listed in brackets.

where 1 maxi bag = 5 to 6 basins,

and 1 maxi bag = 40 bowls

APPENDIX 5 People Met

Ministry of Food and Agriculture (MoFA)

Northern Region

Mr Salifu	Regional Agricultural Engineer
(Prince) H Fuseini	Post Harvest Officer
Harry Gbetroe	acting Post Harvest Officer

Upper West Region

Mr Gyamfi	Regional Agricultural Engineer
Sammy Arku	Post Harvest Officer
Adjei Frimpong	District Agricultural Officer (Bawku West)

Upper East Region

Edmund Otupri	Regional Director of Agriculture
	Regional Agricultural Engineer
James Atiyigiri	Post Harvest Officer
Peter Abugrey	Ass.Dist.Ag.Officer (Bawku East)

University of Development Studies (UDS)

Dr Ditto	Head Socio-economist
Mrs Joyce Bediako	Socio-economist
Richard Yeboah	Socio-economist

Savannah Agricultural Research Institute (SARI)

Mr Mercer-Quarshie	Director
Mr Stephen Aitkins	Workshop Manager (responsible for the two project vehicles)

GTZ

Dr Helmut Albert	Head of GTZ Project (Tamale), Agricultural Entomologist
Dr Peter Bisset	

Tamale Archdiocese Agricultural Project (TAAP)

David Miller	Head of TAAP
Sulemana Stevenson	Project Coordinator
Ralph Ali	

Action Aid

George Owusu	Representative in Tamale
Charles Nyakora	Programme Officer in Bawku

Others

Dr Augustine Dzisi	Ag.Eng. UST (onion storage trials in UE)