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Network on Bean Research in Africa
Reseau de Recherche sur le Haricot en Afrique

ON-FARM STORAGE LOSSES DUE TO BEAN BRUCHIDS AND FARMERS' CONTROL STRATEGIES:

A REPORT ON A TRAVELLING WORKSHOP IN EASTERN AND SOUTHERN AFRICA. 16 SEPTEMBER - 3 OCTOBER, 1992.

Occasional Publications Series, No. 8

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Preface

This publication records the observations, findings and conclusions of a team of bean bruchid researchers and storage entomologists as they travelled through bean growing communities in Uganda, Tanzania and Zimbabwe. They report on post-harvest and storage practices used by farmers for beans, the estimated losses incurred, as well as the bruchid species involved and their distribution. Recommendations on strategies to reduce losses in quality and quantity in storage are also made.

This is the eighth volume in the Occasional Publications Series that serve research on beans (*Phaseolus vulgaris* L.) in Africa. These publications series form part of the activities of the Pan-African bean research network, which aims to stimulate, focus and co-ordinate research efforts on this crop.

The network is organized by the Centro Internacional de Agricultura Tropical (CIAT) through three independent research projects, for the Great Lakes region of Central Africa, for Eastern Africa and, in conjunction with SADC, for the Southern Africa region.

Working documents will include bibliographies, research reports and network discussion papers. These publications are intended to complement an associated series of Working Proceedings.

Support for the regional bean projects comes from the Canadian International Development Agency (CIDA), the Swiss Development Corporation (SDC) and the United States Agency for International Development (USAID).

Further information on regional research activities on common beans in Africa, and additional copies of this publication, are available from:

Pan-Africa Coordinator, CIAT, P.O. Box 23294, Dar es Salaam, Tanzania.

Coordinateur Regional, CIAT, Programme Regional pour l' Amelioration du Haricot dans la Region des Grands Lacs, B.P. 259, Butare, Rwanda.

Workshop Series

No. 1. Beanfly Workshop, Arusha, Tanzania, November 16-20, 1986.

No. 2. Bean Research in Eastern Africa, Mukono, Uganda, June 22-25, 1986.

No. 3. Soil Fertility Research for Bean Cropping Systems in Africa, Addis Ababa, Ethiopia, September 5-9, 1988.

No. 4. Bean Varietal Improvement in Africa, Maseru, Lesotho, January 30 - February 2, 1989.

No. 5. Troisieme Seminaire Regional sur l'Amelioration du Haricot dans la Region des Grands Lacs, Kigali, Rwanda, 18-21 Novembre 1987.

No. 6. First SADCC/CIAT Regional Bean Research Workshop, Mbabane, Swaziland, October 4-7, 1989.

No. 7. Second Regional Workshop on Bean Research in Eastern Africa, Nairobi, Kenya, March 5-8, 1990.

No. 8. Atelier sur la Fixation Biologique d'Azote du Haricot en Afrique, Rubona, Rwanda, Octobre 27-29, 1988.

No. 9. Actes du Quatrieme Seminaire Regional sur l'Amelioration du Haricot dans la Region des Grands Lacs, Bukavu, Zaire, 21-25 Novembre, 1988.

No. 10 National Research Planning for Bean Production in Uganda, Makerere University, Kampala, Uganda, January 28 - February 1, 1991.

No. 11 Proceedings of the First Meeting of the Pan African Working Group on Bean Entomology, Nairobi, Kenya, 6-9 August, 1989.

No. 12 Ninth SUA/CRSP Bean Research Workshop, and Second SADCC/CIAT Regional Bean Research Workshop. Progress in Improvement of Common Beans in Eastern and Southern Africa, Sokoine University of Agriculture, Morogoro, Tanzania 17-22 September, 1990.

No. 13 Virus Disease of Beans and Cowpea in Africa, Kampala, Uganda, January 17-21, 1990.

No. 14 First Meeting of the SADCC/CIAT Working Group on Drought in Beans, Harare, Zimbabwe, May 9-11, 1988.

No. 15 First Pan-African Working Group Meeting on Anthracnose of Beans, Ambo, Ethiopia, February 17-23, 1991.

No. 16 Cinquieme Seminaire Regional sur l'Amelioration du Haricot dans la Regional des Grands Lacs, Bujumbura, Burundi, 13-17 Novembre 1989.

No. 17 Sixieme Seminaire Regional sur l'Amelioration du Haricot dans la Region des Grands Lacs, Kigali, Rwanda, 21-25 janvier 1991.

No. 18 Conference sur le Lancement des Varietes, la Production et la Distribution des Semences de Haricot dans la Region des Grands Lacs, Goma, Zaire, 2-4 Novembre 1989.

No. 19 Recommendations of Working Groups on Cropping Systems and Soil Fertility Research for Bean Production Systems, Nairobi, Kenya, 12-14 February 1990.

No. 20 First African Bean Pathology Workshop, Kigali, Rwanda, 14-16 November, 1987.

No. 21 Soil Fertility Research for Maize and Bean Production Systems of the Eastern African Highlands - Proceedings of a Working Group Meeting, Thika, Kenya, 1-4 September 1992.

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ON-FARM STORAGE LOSSES DUE TO BEAN BRUCHIDS AND FARMERS CONTROL STRATEGIES.

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Introduction

Storage weevils take a heavy toll of harvested beans. These may infest the maturing crop in the field as in *Acanthoscelides obtectus* (Say) or enter the granary or storage facility initially in low numbers and multiply rapidly among the stored produce.

One of the objectives of the CIAT Bean Research network in Africa is to develop low cost technologies with high adoption values among resource poor farming communities.

To do this, it is recognized that it is essential to understand how farmers in such communities store their bean as well as the forces that lead them to adopt different storage practices. As an initial step in this direction, a survey was conducted across small scale bean growing communities in Uganda, Tanzania and Zimbabwe with the following objectives:

1. to determine the distribution of the two major bean bruchid species that infest stored beans in the different agroecological zones in the 3 countries.

2. to familiarize ourselves with post-harvest practices employed by farmers and study the various storage practices used by them.

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Institute of Agricultural Research (IAR), Nazreth Research Station, P.O. Box 436, Nazreth, Ethiopia.

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Sokoine University of Agriculture, Faculty of Crop Science and Production, P.O. Box 3005, Morogoro, Tanzania.

3. to gain an insight into small farmers' perceptions of losses in storage.

4. to determine the farmers' storage policies and end use patterns of beans.

5. to evaluate the efficiency and potential for improvement of bruchid control methods.

Methods

Survey areas and farmer selection.

In Uganda the survey was conducted across the major bean growing ecologies in Mbale, Iganga, Kasese, Kabarole and Mubende areas (Figure 1). In Tanzania the survey concentrated on the medium altitude bean growing environments in Arusha and Tanga regions and the low altitude environments in Morogoro region (Figure 2). In Zimbabwe, the team surveyed only the Guruve district, in the medium altitude belt (Figure 3) because of the drought during the previous year. Table 1 lists the specific locations within districts that were surveyed.

Farmers were selected in each location for the interviews; the number of farmers interviewed depended on the size of the farming community. In some cases a group of farmers happened to be together in one place and they all participated in the discussions. Such farmers were listed as individuals since their individual opinions were recorded separately. Farmer selection was random but selection of location was guided by local field extension staff who advised us as to where beans were grown in a particular area.

Farmer interviews.

Even though a questionnaire was prepared for the collection of data on farmer perceptions or bruchid damage and management practices, there were no systematic "interviews" conducted. Instead discussions based on the points in the questionnaire were held with individuals or groups of farmers and notes were made on the relevant issues. The questionnaires were filled at the end of the day. This approach provided a more relaxed atmosphere in which the farmers gave information freely. The discussions were aimed at obtaining the following information:

Figure 1. An elevation map of Uganda showing areas surveyed.

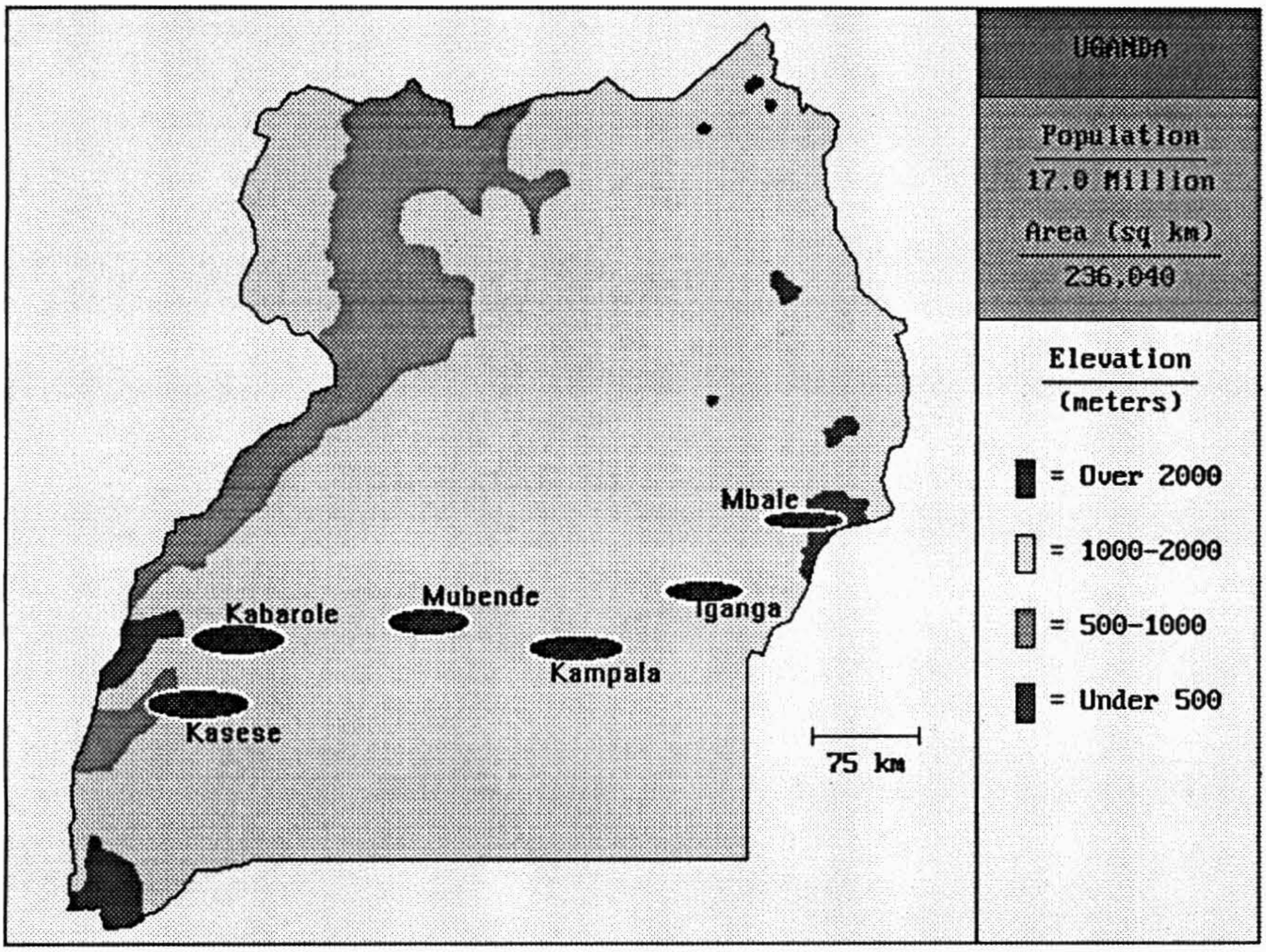


Figure 2. An elevation map of Tanzania showing areas surveyed.

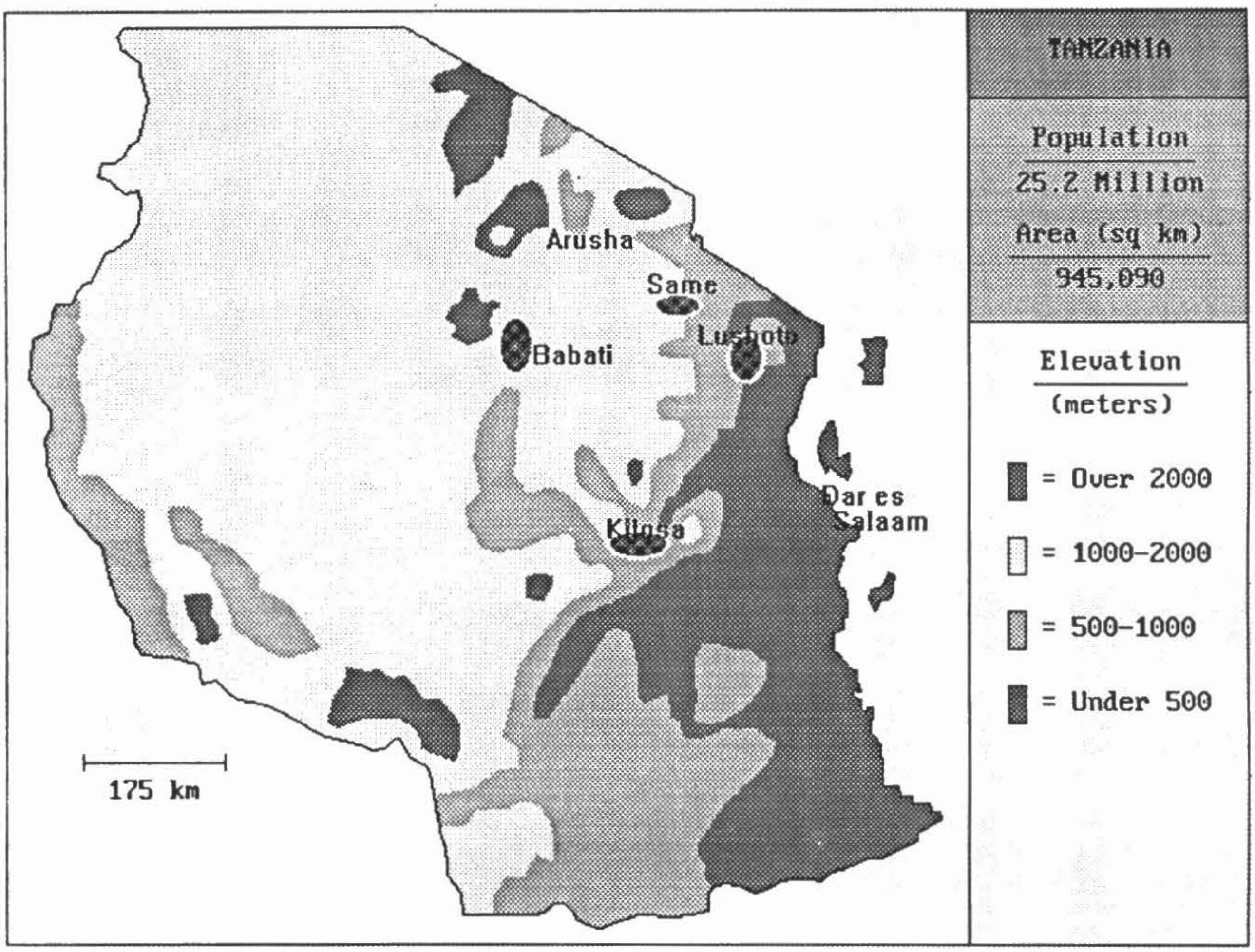
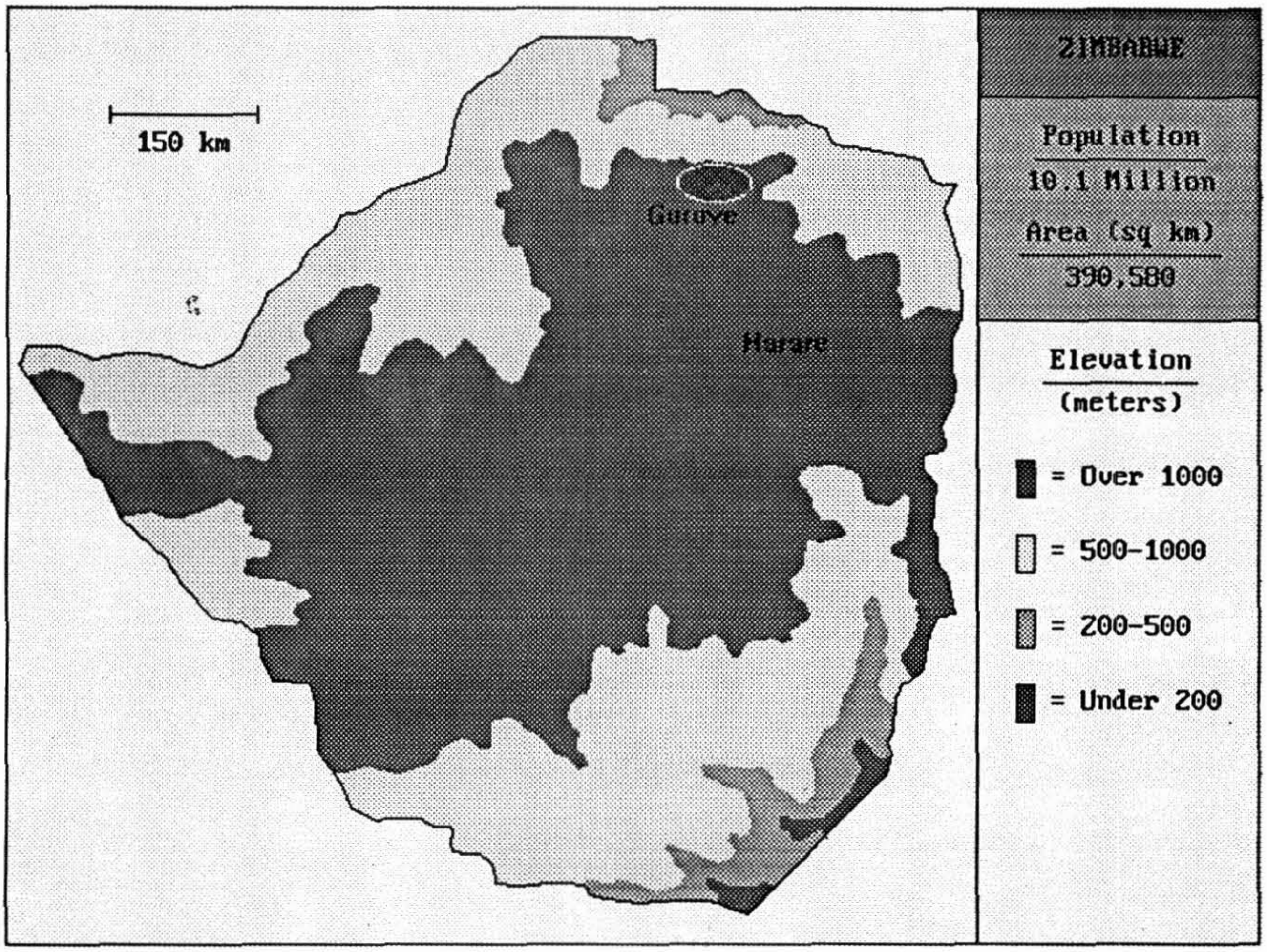


Figure 3. An elevation map of Zimbabwe showing areas surveyed.



i) area under bean cultivation
ii) bean production, use patterns and storage policy
iii) bean cropping systems
iv) drying and harvesting techniques
v) storage problems viz. farmers' perceptions of the seriousness of bruchids as pests in storage
vi) storage and conservation methods practiced by the farmers as well as those he/she is aware of but not practiced
vii) farmers' evaluation of the effectiveness of conservation techniques
viii) awareness of constraints of other conservation techniques practiced
x) farmers' perceptions on the extent of storage losses
xi) species of bruchid of importance in particular regions
xii) time when infestations are first noticed.

Farmers, as well as, bean traders were interviewed and samples of beans from their stores were purchased for culturing and extraction of bruchids infesting them for species identification and assessment of infestation levels.

In addition to the farmer discussions we inspected and took samples from the farmers' granaries to assess the storage conditions and infestation levels. Examination of farmer granaries also revealed information on other biotic and abiotic characteristics of their storage systems.

Conduct of the Investigation

The method of approach was based on informal unstructured interviews with farmers. This approach was used to probe for information and fostered free dialogue to elicit the farmers' needs and their perceptions of the reality of the food (bean) supply, bean storage problems and the efficiency of the methods practiced. The team systemized and recorded everything the farmers mentioned in the discussions relating to post-harvest problems and practices. Appendix I gives the interview guide used. Direct observations provided more specific information on particular biotic and abiotic constraints to storage. Examination of beans collected from farmers' stores confirmed the nature and extent of damage related to the two species of bruchid.

This approach provided a platform on which ideas were shared between farmers and the researchers and a way of gaining first-hand information on the diversity of conservation techniques from farmers. In many instances the team was asked to provide a scientific analysis of the problems and to make critical evaluations of the conservation techniques.

In each area the altitude was recorded and a sample of beans was examined for bruchid infestation as well as species identification to gain more information on species distribution in relation to ecological zones.

Results and Discussion

Bean Production and Cropping Systems

Beans form an important staple food in Uganda and Tanzania and were observed to be very widely grown in the areas surveyed. These two countries are among the largest bean producers in Africa. In Zimbabwe, however, beans are relatively unimportant when compared to other food legumes e.g. cowpeas. Much of Zimbabwe's bean production is from large scale commercial and state farms.

In all 3 countries, the area under bean production in small scale farms varies greatly among farmers and between regions (Table 2). The wide variation in acreage may be explained by the following :

i) in most cases beans are intercropped with other major crops, hence areas quoted usually comprise farms under monocrop as well as intercrop pod beans.

ii) small farmers grow beans in several small patches of land and estimates are likely to be inaccurate.

iii) agricultural potential varies between areas and this influences the composition and amount of different crops including beans, grown there.

In Uganda, the most common crops grown in association with beans are banana, maize and cassava. In the Tororo district of eastern Uganda farmers intercrop cotton with beans. Due to the frequency of insecticide sprays against cotton pests, field pest problems were of no consequence in the bean crop.

In Uganda and in some parts of Tanzania (e.g. Lushoto District) where rainfall is bimodal, most farmers told us that they grow two crops of beans annually. Farmers in Lushoto also cultivate a third crop in the lowlands under irrigation specifically for the multiplication of seeds for the next season. Farmers indicated that this was necessary for good quality seed for the main crop as they were unable to keep seed well protected from bruchids. They were well aware that germination and seedling vigour were poor in bruchid damaged seed.

Table 1. The areas[1] and number[2] of farmers interviewed in Uganda, Tanzania and Zimbabwe

Area	Number of farmers interviewed
UGANDA	
Tororo	2
Mbale	4
Iganga	4
Kasese	8
Kabarole	8
Mubende	2
	28
TANZANIA	
Babati (Arusha)	13
Same (Kilimanjaro)	8
Lushoto district (Tanga region)	16
Kilosa district (Morogoro region)	10
	47
ZIMBABWE	
Guruve	7

[1] Areas represent the major bean producing regions in the respective countries.

[2] In some locations groups of farmers were interviewed together so this total represents the view and or practices of more than total number of farmers listed here.

Table 2. Area under bean production and cropping patterns

Location	Number of farmers	Area cultivated Mean (acres)	Range (acres)	% farmers ntercropping	Major intercrop
UGANDA					
Mbale	4	1.3	0.25-3	100	banana
Pallisa	2	0.6	0.25-5	100	soybean
Iganga	4	5.0	0.5-5	75	maize
Kasese	8	3.2	0.5-7	62.5	maize, cotton
Kabarole	8	6.8	0.25-25	100	maize, cassava
Mubende	2	3.3	0.25-6	50	maize
TANZANIA					
Babati	11	4	1-10	36.8	sunflower
Same (Bombo)	8	1.2	0.25-5	87.5	maize, cassava, sweet-potato
Lushoto	16	2.5	1-7	62.5	maize
Kilosa	10	1.25	0.5-2	70.0	maize, cotton, tomato
ZIMBABWE					
Guruve	6	0.8	0.25-2	58.0	maize

Post-harvest practices:

Harvesting, Drying and Threshing

The drying and threshing techniques used by small farmers in all areas visited were generally similar except for a few notable exceptions. The majority of farmers allow their crops to dry in the field until the required moisture content is reached. Thereafter, whole plants are harvested and brought to the homestead where they are threshed within 1-4 days. In Mbale, however, the wetter conditions necessitate early harvest and drying at the homestead. Here, the harvested plants are tied together in small bundles and hung under the eaves of the roof and sheltered from the rain to dry. In this area the beans are normally threshed 3-4 weeks after harvest.

Most farmers were aware that the beans become heavily infested with bruchids (*A. obtectus*) if harvesting is delayed. Threshing is thus done as soon as it was practical, and seeds are treated with various protectants including insecticides, botanical products or ash and stored in sacks where available, otherwise they are stored in heaps on the floor, in pots and various other containers. Where *A. obtectus* is a problem, timely harvest and threshing, followed by protective treatments are necessary. By contrast, farmers in Babati District (Tanzania) often leave beans unthreshed in temporary storage at the homestead for periods of up to 2 months to dry. Time of threshing is influenced by the work load and other farm or social activities. The farmers felt that there was no urgency in threshing and applying any treatment as the beans were well protected from bruchids in the pods. This was confirmed when *Z. subfasciatus* infestations were observed in threshed beans but not in the unthreshed. It is well known that *Z. subfasciatus* are unable to infest beans in the pod. Farmers however, indicated that bruchids (only *Z. subfasciatus* were observed) become a serious problem later in the storage season when temperatures are high.

Threshing is usually done by beating the pods with sticks. However, where harvests are large (e.g. Babati), farmers may drive a tractor over the pods to separate the beans from the husk.

In Uganda farmers appeared to store beans at high moisture contents. All samples examined(June/July harvest) which had been in storage for 3 months had significantly higher moisture levels than those samples examined in Tanzania and Zimbabwe. The high humidity in Uganda made it very difficult to dry the beans below desired moisture levels for storage. Many farmers also attributed high losses to fungal infection. It is therefore, not surprising that bruchids are of major economic importance in Uganda.

Farmers' Storage Policies

Many factors influence farmers' decisions on how much to store and for what period. Almost all farmers interviewed across regions store a proportion of the harvest for home consumption and a proportion also for seed (Table 3). Only a small minority sold the whole produce soon after harvest for their immediate cash needs. The quantities stored for home consumption and seed were fairly uniform among farmers in a particular area. The quantities stored for sale and the periods of storage however, varied considerably between farmers depending on the season, marketing systems, infrastructure, price and cash needs. Apart from storing for seed and household use, some farmers also deliberately store part or all of their produce intended for the market to await higher prices. Due to the abundant supply of beans soon after harvest (e.g. in Lushoto in Tanzania and Mbale District in Uganda), prices tend to be depressed at the time of harvest and begin to rise a month or two later, reaching a peak just before the next harvest when the demand is at its highest. Farmers that store the produce to take advantage of higher prices however, risk storage losses (infestation by bruchids) and most take protective measures to minimize such losses. Inability to protect beans effectively against bruchids forces farmers to sell within 2-3 months. A large number of the smaller farmers are unable to take advantage of higher prices later in the season because of immediate cash needs. However, many farmers tend to sell part of their produce to satisfy the immediate cash needs and store the remainder to sell as and when cash is needed. Some farmers are forced to store because of poor infrastructure such as poor roads, lack of transport and poor marketing outlets.

The data in Table 3 indicates that 55-82% of the produce is sold, 9-38% kept for household use and 9-34% kept for seed. The figures for Bombo village (Same District, Tanzania) were quite different in comparison to other areas. Sales were much lower than quantities retained for food and seed. Their remoteness, inadequate access to markets, and small harvests are possible reasons for this.

Farmers in the Guruve area of Zimbabwe grow both Michigan pea bean and sugar beans; the former being grown on contract for a local canning company. The Michigan pea bean is thus sold immediately after harvest whilst sugar beans are retained for home consumption.

According to the farmers, the beans are sold as early as possible after threshing; the major reasons for selling the bulk of the crop soon after harvest is the risk of bruchid damage and cash requirements.

Storage Techniques

All farmers store beans in the threshed form; only those farmers in Babati (where *Z. subfasciatus* is predominant) keep beans unthreshed for fairly long periods (up to 3 months). These unthreshed beans are kept in heaps on the floor in the storage area. Because of the presence of *Z. subfasciatus* in the areas visited in Babati, the delay in threshing does not pose any problems because *Z. subfasciatus* is unable to infest beans in the pod. Further, farmers mentioned that the bruchid infestations only become of concern later in the year when temperatures rise.

Table 3. Bean production per household and end-use pattern

Location	Production (in 100kg bags)			End use pattern (% of harvest used for):		
	Number of farmers interviewed	Mean	(Range)	Sale	Home Consumption	Seed
UGANDA						
Mbale + Pallisa	6	3.3	(0.3 - 1)	66.4	22.8	10.8
Iganga	4	25.0	(20 - 35)	82.0	9.0	9.0
Kasese, Kabarole and Mubende	18	13.4	(0.3 - 25)	77.3	12.4	10.3
TANZANIA						
Babati	13	10.1	(1 - 10)	72.0	12.8	15.2
Same (Bombo)	8	1.6	(0.3 - 5)	28.1	38.1	33.8
Lushoto	16	7.7	(1 - 7)	54.6	31.3	14.1
Kilosa	10	1.3	(0.5 - 2)	65.7	25.3	9.0
ZIMBABWE						
Guruve	7	1.4	(0.3 - 4.5)	65.9	17.4	16.7

All farmers find it convenient and easy to store beans in the threshed form. The most common method of storage across all regions was in gunny bags. Small quantities, of seed are kept in a variety of containers such as clay pots, tins, paper or plastic bags. A common practice in Tanzania (Lushoto and Babati) and in

Uganda (Kabarole) is to store beans in heaps on the floor in a store room; a few may store in traditional granaries of woven twigs and mud plaster raised above the ground on wooden platforms and sheltered indoors.

Conservation Techniques for Pest Management

The hazard of post harvest-losses is widespread in small farmer storage systems and as a result, farmers invariably take some measures, both traditional and modern, to avert the losses. There is considerable variation among regions in the techniques used, due not only to climatic and socioeconomic factors but also to variations in culture and preferences. Our surveys focused on farmer perceptions of pests and the methods used to deal with them. Table 4 lists the main practices used in the management of post-harvest losses by farmers in the regions surveyed.

Table 4. Post-harvest management practices for the reduction of storage losses.

Traditionally Derived Techniques

i) variety selection
ii) sun drying (sunning)
iii) sorting damaged grain at harvest
iv) admixing of grains with plants or plant parts having pungent odours (botanicals)
v) mixing ashes with beans
vi) enrobing bean seed with mud and drying in the sun
vii) mixing vegetable oil with beans
viii) storage in clays pots, gourds, traditional granaries
x) granary hygiene.

Modern Techniques

i) chemical pesticides (grain protectants)
ii) use of grain bags/plastic bags
iii) market sales.

The variety of conservation techniques encountered are listed below and briefly discussed here.

Variety Selection

Different cultivars vary in their ability to resist storage pest damage and farmers are often aware of this. Farmers may grow several cultivars each season for many reasons viz. maturity time, colour, taste preferences etc. Although there was no evidence from our discussions with farmers that bruchid resistant cultivars are available; farmers did indicate varietal differences in storability. Better storability is one criterion for variety selection. In Lushoto District several respondents indicated that cv. "Soya" is the first cultivar to become infested in the field and in storage and is comparatively the most susceptible cultivar. Some farmers in Bombo village mentioned the local cv. "Ngombezi" to be resistant. Zimbabwean farmers observed that the Michigan pea beans were generally less susceptible than the sugar beans

Sunning (solar disinfestation)

The relation between moisture content and susceptibility to spoilage is well understood by farmers. Grains are dried in the field for several weeks after physiological maturity before they are harvested and stored. If conditions are moist at harvest, farmers repeatedly spread the grain near the homestead during sunny periods until it is considered dry enough for storage. This was determined by the sound they made when seeds are rubbed against each other or their resistance to biting. Thereafter, farmers regularly expose the grain to the sun for bruchid control. Sunning tends to have the following positive effects :

i) the heat drives out adult bruchids and
ii) eggs and possibly larvae are killed if surface temperatures are high enough.

The success of this technique depends on the frequency at which the grain is sunned. The frequency varied considerably (among farmers) from once a week to once a month. Those farmers who practiced sunning regularly were satisfied with the efficiency of the technique but acknowledged that it was laborious and time consuming. The technique is common in Uganda and Tanzania (Table 5) and is often combined with other treatments such as admixtures with ash or other plant products. Another benefit of regular sunning is that during the handling process, bruchid (*A. obtectus*) eggs are mechanically removed in a manner similar to sieving. However, the benefits of solar disinfestation are reduced if eggs are not removed from the bags/containers in which the beans are stored. The benefits of solar disinfestation, the effect of sunning frequency and duration on the mortality of different stages of the insect merit further study.

Table 5. Percentage[1] of farmers using different conservation techniques.

Methods	Uganda n = 27	Tanzania n = 47	Zimbabwe n = 10	Total n = 84
Soil	21	20	-	23
Sunning	52	68	-	120
Ash	15	26	10	51
Botanicals	18	7	-	25
Insecticides	14	47	90	70
Other	-	2	-	2
No control	18	-	-	18

1 Multiple responses in some cases

Admixing Ashes and Soil

Mixing powdery substances with grain, in order to protect it against insect infestation, is a traditionally based, time-honoured and universal practice that is still used in many parts of Africa. There is a variety of different materials which farmers add to their produce viz. fine sand, clay dust and wood ashes. In our limited surveys, 39% of Ugandan and 28% of Tanzanian farmers were found using ashes or soil admixtures.

Bruchid damage in such treated grain is not totally prevented but newly hatched insects are hindered in their activities. The fine particles of the additives kill the adult insects by abrading their exoskeletons (causing dehydration) and interfering with respiration by clogging up the spiracles. They also inhibit oviposition and movement by filling the intergranular spaces. Whatever the mode of action, there is ample evidence of their effectiveness. The mode of action of these treatments, however are not fully understood nor appreciated by farmers. Their effectiveness, depends on the size and quantity of the particles (finer particles are more effective) and about 3-4kg of substance per 100kg of beans are required to be effective. Wood ash was the most common substance used by the farmers in the areas visited, with the exception in Babati where ash derived from cow or goat dung was used. The amount of ash or soil used by the farmers was very variable, ranging from less than 1kg to 4kg per 100kg beans. It is therefore, not surprising that some farmers achieved adequate control whilst others regarded the technique as ineffective and discontinued using them. The ineffectiveness may be attributed to the low rates and lack of a thorough admix to ensure that all intergranular spaces are well filled with the substance. Farmers who used ash indicated the following associated side effects: tainting and discoloration of seed, as well as the quantity of ash needed to be effective. Many farmers indicated that the method was inconvenient as the grain required thorough cleaning before cooking and therefore restrict its use to seed only. These treatments are often used in combination with other conservation methods such as solar disinfestation (sunning) and admixture with plant products, each adding a degree of protection.

The use of ash may be encouraged wherever it is practicable, such as in small seed storage. In the case of fine sand, even larger quantities are required for effective action. For household use, this method is clearly of value, but it cannot be extended to the marketable surplus, as it means that the grain must be cleaned prior to sale.

Botanicals (Plant Products)

Traditionally many different types and parts of plants are used against storage pests. This traditional practice however, is being replaced by more modern methods such as insecticides which have become more easily available and convenient to use.

Although promising results have often been reported in laboratory tests, the efficacy of botanicals under practical storage conditions is limited. Many farmers however, believe in their effectiveness and experiment with variations of plant products as grain protectants. Plant products are used, usually in combination with ashes and sunning but rarely alone. Farmers' evaluations of plant products as grain protectants rated from poor to good.

The following substances were mentioned by respondents:

UGANDA

Mbale	-	banana juice, pepper
Kabarole	-	Mexican marigold (*Tagetes minuta*), eucalyptus leaves
Kasese	-	pepper

TANZANIA

Bombo village	-	*Tephrosia* (mkala), pine leaves, cardamon, lemon grass (manvenyi leaves), nutshell of "matweme"
Lushoto	-	"iduri" leaves
Kilosa	-	tobacco dust, groundnut oil.

The way in which plant substances take effect is complex and not only restricted to physical properties. Toxic, growth regulating and repellent properties of many such substances are known. However, the real value as grain protectants and safety to the consumer needs to be established. *Tephrosia* for example, is a highly toxic plant whose effects on humans are not well known, yet it is commonly used by farmers in Bombo village. The results of adding edible vegetable oils (e.g. sunflower, cotton seed, groundnut) are much more conclusive but generally not adopted by most farmers interviewed. Only one farmer in Kilosa mentioned using groundnut oil as a protectant, but regarded it costly and had discontinued using it. The oily film protects the beans from infestation for at least 6 months without affecting germination capacity and without danger to the consumer.

Insecticides

Traditional methods have a limited degree of control and consequently farmers are turning to chemical control methods despite some of their shortcomings. Insecticides have become one of the most widely used methods of storage pest management at the small scale farmer level. However, its prevalence in any particular area and between areas varies considerably (Table 6) depending largely on the availability, cost, awareness of safety, convenience and correct usage and influence by extension workers. In Kasese for example, insecticide are discouraged because of the method of planting: during planting, farmers place the beans in their mouths and 'spit out' one seed at a time into planting holes as they are dug. Clearly, any toxic compound added to the seed would be extremely hazardous.

Table 6. Percentage of farmers using insecticides

Area	Percentage
UGANDA	
Mbale and Pallisa	0
Iganga	0
Kasese	25
Kabaroie	37
Mubende	0
TANZANIA	
Babati	100
Bombo	40 (seed only)
Lushoto	15
Kilosa	30
ZIMBABWE	
Guruve	90

In Tanzania, the majority of farmers are aware of Super Actellic (pirimiphos-methyl and permethrin cocktail) for use as a grain protectant. This is probably a spin-off effect from the training and post-harvest extension programmes aimed at controlling the larger grain borer (LGB), *Prostephanus truncatus* in maize. But despite the well established extension service in Tanzania, many farmers still apply non recommended insecticides on beans e.g. in Kilosa farmers indicated that application of "cotton insecticides" particularly on seed was a common practice. In Babati, almost all respondents used Super Actellic while in other regions (Bombo, Lushoto and Kilosa) although farmers were aware of insecticide and its advantages, its use varied. Reasons given for not using the insecticides more frequently were its high cost and poor availability. In Uganda, Actellic is recommended but not widely used mainly because of its prohibitive costs, unavailability and hazard risks. Furthermore, farmers have lost confidence in insecticides because adulterated or 'fake' chemicals are sold by unscrupulous traders. The problems are further compounded by traders selling repacked unlabelled insecticides with no instructions on application and safety. Insecticides are very widely used in Zimbabwe and are very easily available.

Concomitant with the transformation from the subsistence farming system to the cash economy is the expansion in pesticide use and the decline in traditional practices.

Post-harvest Sorting

Separating damaged and infested grains from the rest of the harvest is a very common practice that is generally performed by women and children. Grain that show severe signs insect infestation (bored grains, or showing 'windows') are separated from apparently undamaged grain. Infestations by *Z. subfasciatus* are characterized by eggs attached onto the testa and are easily discernible. The hidden infestation of *A. obtectus*, however, cannot be easily identified. The degree to which sorting is done and the selection criteria used vary by individual household, as well as the size of the total harvest, amount of labour available etc. The impact of sorting out infested or damaged grain in limiting post-harvest damage and possible ways in which it might be improved are worth further investigation. It is well known that germination and plant vigour are less than optimum if damaged seeds are planted. Thus, at sowing, seeds are routinely sorted to remove damaged grain.

Storage Hygiene

Store hygiene is a preventive control strategy that includes removing all previous season's grain, dust, dirt and residues from storage facilities and making the necessary repairs to granaries. Store hygiene is recommended as a management strategy to remove residual populations that would be a source of infestation in a fresh harvest brought for the store. Many farmers however, store the grain of the new crop near grain from an older crop or in the same gunny bags and containers. Insects from the older crop quickly migrate to the new crop. In the case of *Z. subfasciatus* store sanitation is of even greater importance because the insect is a poor flyer and infestations are established from infested residual grain.

A summary of post-harvest practices and conservation techniques adopted by small scale farmers in the countries surveyed are given in Tables 7 (a, b and c) respectively.

Post-harvest Losses and Hazard Assessment

One of the critical problems that all small farmers face is storing produce with minimal losses. If not successful, they may suffer considerably high losses. To minimize the damage a range of conservation techniques have evolved over the years by trial and error to suit farmer's particular circumstances. These practices are tied to the causes and perceptions of the problems and judgements about what comprises effective responses. Most farmers in our survey areas regarded bruchids as the major constraint to safe storage and carried out some form of pest control. Under ideal conditions for storage pests infestation (e.g. high moisture content and temperature), loss can be near total within a short period if the produce is not protected. Despite the short storage periods, especially in Uganda and parts of Tanzania, where two crops are harvested and stored per year, storage losses are still considered to be unacceptably high by farmers. In the case of *A. obtectus* infestations commence in the field and multiply very rapidly in store, thus contaminating and damaging the produce within a very short period. Apart from suffering a quantitative loss, the qualitative loss may be more important, having a significant impact on marketing policy and prices. The acceptable threshold of infestation by bruchids is considerably lower than cereals. In the case of *A. obtectus*, infestations may be severe but not apparent due to the "hidden - infestation". However, farmers are able to distinguish the decline in quality due to the intense characteristic odour emitted by the bruchid. Though loss may be low in terms of dry weight after 3-4 months in storage, the multiple holes on the seeds reduce the value of the grains to such a level that the farmers considered it a total loss. Farmers are often forced to sell their beans earlier than intended, and in some cases accept a lower than the prevailing market price because of some real or fear of damage to the crop storage. The value of the crop is not based on the extent of visible damage and dry weight loss but on the quality of grain. It is for this reason that most farmers indicate that total loss occurs after 4-5 months in store. During our survey, examination of samples showed very little visible damage due to bruchids. However, it was often quite obvious from the odour that the grain was infested. On-the-spot estimates of loss was not possible for *A. obtectus*, thus samples of beans were randomly collected for incubation and subsequent damage assessments.

Factors affecting storage losses include the degree of infestation that occurs in the field, the resident population in the farmer's store (from previously stored crops) the moisture content of the beans, temperature and humidity conditions and a wide range of harvest and post-harvest practices. A number of farmers (in *A. obtectus* areas) were unaware that infestations commence in the field. However, several commented that the longer the crop is left in the field to dry, the greater is the problem of bruchids in storage. A small number of farmers noticed infestations at harvest, but generally most of them noticed the infestations a few weeks later. All farmers perceived bruchids as the most serious storage problem and indicated that noticeable infestations are observed approximately 0.5-1 month after placing the beans in the store and serious damage occurs after 2-3 months. In Babati (a *Z. subfasciatus* area), farmers observed that infestations become noticeably serious 3-6 months after harvest. However, it should be noted that most farmers in this area use Super Actellic and infestations would therefore only become evident once the effects of the insecticide begin to ware several months later. Furthermore, all farmers indicated that *Z. subfasciatus* infestations arise later in the year when temperatures rise. The fact that beans are routinely treated with insecticides in some places indicates that bruchids are pests that warrant control measures.

In our surveys nearly every farmer suggested total loss occurs after 3-4 months in storage if they do nothing to prevent the pest infestation. Farmers were unable to accurately estimate the weight loss if treatments were carried out but responses varied from no loss if insecticides were used, to over 50% loss with other traditional measures.

Table 7a. Summary of post-harvest practices: Uganda

Practice	Mbale + Pallisa	Iganga	Kasese	Kabarole	Mubende
Drying	In field and homestead. Wet conditions necessitate early harvest and drying in the homestead for upto 21 days in eaves or veranda of house, on ground if sunny conditions prevail.	In field. Homestead drying for 1 day.	In field. Homestead drying for 1-3 days.	In field. Homestead drying for 1-4 days.	In-field. Homestead drying for 1-4 days.
Variety selection for storability	Storability probably secondary to colour and taste; most common cv K20, but several other cultivars available including local landraces.				
Sunning	Very common; often combined with soil admix; frequency: every 2-4 weeks; variable effectiveness.	All farmers; frequency every 2-4 weeks; variable effectiveness.	Uncommon	Very common frequency every 1-2 weeks. Very effective if done regularly or combined with other treatments.	Common, frequency every 2 weeks, usually combined with other treatments, variable effectiveness.
Ashes	Uncommon.	Uncommon	Common, sometimes in combination with plant products; poor to satisfactory control.	Applied as powder or slurry.	Common often in combination with plant parts such as *Tegetes* or *Eucalyptus* leaves and pepper. Application rate variable; effectiveness poor to satisfactory, depends on amount of ash used.

Table 7a. Continued

Practice	Mbale + Pallisa	Iganga	Kasese	Kabarole
Botanicals	Banana juice, pepper effectiveness variable.	-	Pepper effectiveness variable.	Leaves of *Eucalyptus* pepper effectiveness good, best used in combination with ash and sunning methods.
Insecticides	Not very common Actellic and unknown insecticides, often repacked and unlabelled by traders. Some mentioned DDT.	Uncommon but most aware.	Uncommon but most aware, Malathion and Actellic mentioned.	Uncommon, not used due to planting techniques (spitting) and discouraged by extension.
Sorting grain	Common practices	Common practice	Common practice	Common practice

Table 7b. *Summary of post-harvest practices: Tanzania.*

Practice	Babati	Bombo	Lushoto	Kilosa
Drying	In field and homestead. Drying at homestead may be extended upto 2 months depending on workload.	In field and homestead drying 1-14 days.	In field and homestead drying 1-2 days.	In field and homestead drying 1-3 days.
Variety selection (for storability)	cv. "Iringa" most common.	Wide range of improved and local cvs. grown. Preference for colour, cookability and taste.	cv. "Soya" most susceptible but still widely grown. cv. "Lyamungu 85" least susceptible and most preferred.	Several types grown, cv. "Lyamungu 85" most common.
Sunning	Uncommon	Very common, usually combined with other techniques; frequency every 2-4 weeks; effectiveness varies from good to satisfactory.	Very common often combined with other techniques; frequency every 1-4 weeks; effectiveness varies from poor to good.	Very common, frequency every 1-4 weeks; effective if done frequently.
Ashes	Common, cow and goat dug ash, rate of application 1 kg per bag. Quite effective but not as good as insecticide, usually applied to grain retained for food only.	Very common, especially on seed treatment. Usually combined with plant products and sunning. Application rate - 2 kg per bag; effectiveness satisfactory.	Few farmers use ashes, but all farmers aware and have used it in the past, considered ineffective because of low application rates, inconvenient.	Common, applied as dust or slurry. Application rate very variable upto 10 kg per bag. Rate as very effective but inconvenient, usually applied to seed.

Table 7b. Continued

Practice	Babati	Bombo	Lushoto	Kilosa
Botanicals		*Tephrosia*, pine needles, cardamon "mevenyi", "matweme". Effective because used in combination with other methods.	"Iduri" leaves in combination with sunning.	Tobacco dust and groundnut oil, very effective but not common because of high cost.
Insecticide	Very common, Super Actellic used, easily available and affordable. All produce treated including food, seed and marketable surplus. Very effective.	Sometimes used by farmers only on seed. Awareness of insecticides but unaffordable.	Not common; some farmers would use if available.	Not common; insecticides often incorrectly used e.g. 'cotton insecticide' applied to seed.
Sorting grain	Common practice	Common practice	Common practice	Common practice.

Table 7c. Summary of post-harvest practices: Zimbabwe.

Practice	Guruve
Drying	In field and homestead 1-7 days.
Variety selection (for storability)	Michigan pea bean incurs less damage compared to Natal Sugar and Red Kidney beans.
Sunning	*Uncommon.*
Ashes	Sometimes, used, efficacy very variable depending on application rate.
Botanicals	Uncommon.
Insecticides	Very common, e.g. Actellic (Shumba) and Malathion.
Sorting grain	Common practice.

Distribution of Bruchid Species

Literature suggests that *A. obtectus* is restricted to the cooler environments (higher altitude and latitude) where it infests beans in the field and in storage. In contrast *Z. subfasciatus* is a warehouse pest and confined to warmer (lower altitude) areas. The two species appear to differ in ecological adaptation and whilst in South America the distribution of the two bruchid species is clearly defined according to altitude (Schoonhoven and Cardona 1986), no such relationships were found during our monitoring survey in Uganda, Tanzania and Zimbabwe. Previous surveys, in Uganda (Silim, 1990) showed both species are well established and widespread in Uganda, both were found in all agroecological zones. However, the percentage composition of the two species varied between ecological zones, between rural and urban centres and among rural areas of the same zone. In samples from most urban centres, *Z. subfasciatus* predominated with the highest percentage composition found in the corridor running between Entebbe - Jinja - Tororo - Soroti. Pockets of high populations were also found in the towns of Lira and Apac. *Z. subfasciatus* also predominated in samples from rural areas with the largest percentage composition in zones II and IV. In our monitoring survey (during September 1992) no *Z. subfasciatus* infestations were observed except for a few isolated cases at the Produce Marketing Board (Kampala) and Mbale market.

A. obtectus was found to occur in areas ranging in altitude from 600-1600m in Tanzania with one notable exception (Table 8). Infestations of *Z. subfasciatus* only were observed in Babati District (altitude 1500). According to the farmers, infestations of *Z. subfasciatus* commence approximately 2-3 months after storage and necessitate insecticide treatments for protection. By contrast, in Kilosa (altitude 600m) only *A. obtectus* was observed. Previous surveys in the same area by Masolwa and Nchimbi (1991) however, showed that both species were present with *Z. subfasciatus* being more predominant. Farmers easily recognized beans bearing *Z. subfasciatus* eggs and indicated that such infestations rise with increases in temperature from October onwards. We were however, unable to determine whether, in fact, farmers were referring to *Callosobruchus* infestations which are common on cowpeas and pigeon peas in that area, or to *Z. subfasciatus*. Masolwa and Nchimbi (1991) observed *Z. subfasciatus* as the predominat species in the Arusha, Morogoro and Dodoma Districts (altitude 350-1800) during the period between March and August, irrespective of altitude. *A. obtectus* was the only species observed in the areas monitored during our study. However, interviews with traders, store managers and farmers revealed that *Zabrotes* does occur, but infestation commence later in the year when temperatures are high and beans are stored for long periods. Furthermore, we infer that, infestation by *Z. subfasciatus* arise if there is a carry-over of stocks in storage from one season to another. The presence or absence of *Z. subfasciatus* in any particular area appear to be dependent on the time in the season the surveys are conducted. Surveys conducted during the hottest months and later in the storage season may show *Z. subfasciatus* to be predominant whilst *A. obtectus* may be of lesser importance at that time of the year. These observations may explain some of the contradictory and conflicting results of surveys by Davies (1972) in Uganda.

The range of altitudes and ecological zones in Tanzania in which the two bruchids species occur suggests that both species have a wide range of adaptation in Africa. Many questions on the distribution, abundance and timing of infestations in Africa viz. Uganda and Tanzania now arise :

Why is *Z. subfasciatus* more predominant and why do localized pockets of *Z. subfasciatus* occur in places such as Babati ?

What are the limiting factor(s) determining spread of the species ?

Table 8. Bruchid species recorded in different areas and altitude

UGANDA	Altitude (m)	Species	Comment
Mbale	1500	Ao, Zs	Low Zs infestation observed in local market.
Pallisa	1400	Ao	
Iganga	1400	Ao	
Kasese	1000	Ao	
Kabarole	1300	Ao, Zs*	Traders in local market aware of Zs on produce originating from Mwenge area.
Mubende	1300	Ao	
Kampala	1200	Ao, Zs	Very low infestation of Zs observed at Province Marketing Board deposit.
TANZANIA			
Babati	1380	Zs	
Bombo	1320	Ao	
Lushoto	1200	Ao, Zs*	Zs, from September.
Kilosa	600	Ao, Zs*	Zs from October.
Kilimanjaro	1040	Ao, Zs*	Very low infestation Kwasadala market, Zs occurs later in the year.
ZIMBABWE			
Guruve	1360	Ao	

Ao = *Acathoscelides obtectus*; Zs = *Zabrotes subfasciatus*
* = Species not seen, but described by farmers and traders.

Why do the results of different surveys differ so significantly?

Is the presence or absence of *Z. subfasciatus* or *A. obtectus* in any particular area dependent on the time in the season surveys are conducted ?

What are the upper and lower temperatures limits that the African strains of *A. obtectus* can tolerate ?

Are there strain differences in *A. obtectus* and *Z. subfasciatus* from the different agroecological zones?

To what extent do interactions between the two species determine abundance and spread ?

This monitoring tour has shown that the distribution of bruchid species in Africa is not clearly defined. The situation is much more complex than previously thought.

Recommendations

1. The distribution of the two dominant bruchid species: *A. obtectus* and *Z. subfasciatus* in Africa is poorly understood. Their distribution patterns do not seem to follow any establishment patterns. We recommend that a systematic study of their population patterns in different agroecological zones to gain a better understanding.

2. Data on bruchid species distribution in Africa are inconsistent and sometimes contradictory perhaps because of different times of surveys. We suggest that systematic surveys be done over long periods to establish the distributions pattern and changes, if any, in species dominance in relation to time. There is also a need to undertake comparative studies under controlled laboratory conditions on temperature adaptations the different bruchid species affecting beans.

3. *Z. subfasciatus* infestations tend to be serious in urban stores and when farmers store over a long period. We suggest a detailed study on the ecology and population development in rural and urban stores. Farmers should also be educated in storage hygiene and other measures for the prevention of bruchid infestation and damage.

4. Small scale farmers use a range of traditional conservation practices with varying rates of protection. We suggest that standardized evaluations be carried out with farmers under farmers' conditions to encourage efficient use and adaption of the conservation practices.

5. Solar disinfestation/sunning is a widely used practice. We encourage studies on the optimization of this technique i.e. to improve the amount of heat generated to kill the insects without affecting seed viability as well as the frequency of sunning to prevent reinfestation.

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Appendix 1. Questionnaire on Farmer Perception and Control of Bruchids

Region________________________ District______________________________________

Village ________________________ Farmer Serial No. ______________________________

Person interviewed M F Age 20 20-30 30-40 40-50 > 50 (circle)

Explain : Who you are : Research from national program : interested in beans - farmer concerns in bean storage.

Bean Background

How long have you been growing beans ? ______________ Seasons per year ______________

Do you have idea of beans harvested, last season ? ______________________ estimate (kg? baskets ?)

What did you do with beans after harvest : (may check several)

Store ____________ Sold ______________ Consumed ______________ Other ____________

If you stored them, for how long ? ____

Did you thresh them or leave them in pods ? T _______________ P _________________

For how long did beans stay in pods before threshing ? __________________________________

How did you store them :

Pots _________ Gunnysack _________ Drum _________ Other (specify) ____________

Storage (General)

Do you have storage concerns ? Y _______ N ________

List major concerns:

1. ____

2. ____

3. ____

4. ____

If bruchid not mentioned. Show farmer insect. Ask :

Have you seen this pest ? Y ___________ N ___________

Is this pest a concern for you ? Y __________ N __________

If no, why not. ____

____

Storage : Focus on Bruchids

A. Perception

You mentioned "bruchids" as a problem : What portion of your harvest would you assess is generally affected?

< 1/4 1/4 1/2 3/4 > 3/4

Is the problem worse one season than another Y _________ N _________

Which___________ Why?____

Do you think the problem's changing over time Y ________ N __________

How ______________ Since ______________ Why _____________________
(direction) when.

What factors do you think affect the problem ? _____________________________

____

____

____

Are some varieties more susceptible than others ? Y ___________ N _________

Which____

Which varieties do you grow ? ____

B. Control

How are you currently controlling the bruchid problem ?

1) a. Insecticide ________________	2) a. Ash ____________	3) a. Plant product______
b. date of purchase_____________	b. tree species______	b. processing________
c. dosage __________________	c. quantity___________	c. quantity__________
d. portion of harvest treated____	d. portion treated______	d. portion treated ___

How do you judge the effectiveness of the method you use ?

Other effective	Moderately effective	Very effective

Why did you choose this method ?

Have you ever used any other methods ? Y ________ N _______ Which ________
(separate listing each method)

Method ________________	________________	________________
When used ______________	________________	________________
Effectiveness ____________	________________	________________
Why not used ____________	________________	________________

Comments:

Do you know other methods ? Y _________ N _________

1. Minerals 2. Oils 3. Ash

4. Plant chemicals 5. Sun drying 6. Mixing with sand

7. Chemicals 8. Other (specify) : (Circle appropriate).

Specific reasons for Not using methods.

1.____

2.____

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

DIRECT OBSERVATIONS ON STORED BEANS.

Ask the farmer (kindly) to show you the beans he has stored.

1. Ask the farmer to show you a handful of beans he will plant.

   If handful contains beans with bruchid damage - ask if he will plant "this" If "yes" - ask if there is a difference between bean with "few" holes (show) and "many" holes (show). Try to determine limits of what farmer considers "damaged" beans.

   Notes:

2. Ask the farmer to show you handful of beans he will consume (repeat process step 1).

   Notes:

3. Look at stored harvest with farmer : Ask him if he considers the damage as :

a) none at all	b) little
c) significant but not serious	d) serious (or your relevant categories)

4) Mix the beans in the containers thoroughly. Scoop a cupful from the container. Put beans on the floor with paper. Spread and count the damaged beans. Estimate the proportion of spoiled beans or place the beans in a set of shakers and shake to separate beans from bruchids. Collect the bruchids, put them in a container and return the beans to the farmer.

Background Information

1. How many years have you been an independent farmer ? ____________________

2. Who is head of your household ? ____________________

3. Ask farmer : (You have answered so many of our questions) - Do you have any questions for us ?

OBSERVATIONS:

1. Appraise farmers response:

   . Was he cooperative or was he eager to get rid of you.

   . Do you think he answered your questions honestly ?

   . Your impressions.