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POST-HARVEST STORAGE PROBLEMS OF DRIED CASSAVA AND SWEET POTATO IN TANZANIA

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SUMMARY

1. Surveys were conducted to determine storage losses due to insects and moulds, in dried cassava and sweet potato products, in eight districts of Tanzania. Areas were selected on the basis of their importance for either of the crops for production, or household food security. The survey was conducted in two stages. The objectives of the first stage, carried out during the rainy season, were to gather general information on harvesting, processing and storage techniques. The objectives of the second stage, undertaken during the dry season, were to obtain a quantitative assessment of storage losses in dried products, to determine if losses due to insects or moulds were limiting factors to household food security, and to provide recommendations for any necessary future work. Rapid rural appraisal techniques were used to gather data, in order to obtain an overview of the situation with limited personnel resources. In total, forty villages were included in the surveys. In the first stage, village-based group interviews were conducted; in the second, data was gathered via individual interviews with randomly selected householders throughout the village.

2. Results from both stages indicated that insect losses are perceived as more important than any deterioration due to moulds. Moulds are deliberately encouraged to grow during the production of many of the fermented products, which assist in cyanide release. Moulds were perceived more as a quality issue, with certain types producing a better flavoured final product, corresponding to a more efficient fermentation. The deliberate encouragement of mould growth on products at high water activities is likely to inhibit the growth of mycotoxigenic fungi. There was very limited evidence of mycotoxin contamination of *makopa* samples.

3. A visual grading scale developed for measuring cassava losses in West Africa was adapted for use with both cassava and sweet potato products. Production of sweet potato products was much lower than in other years, due to a drought within Lake Zone. Losses in sweet potato products were much lower than in cassava products, for a comparable storage period. Actual weight losses due to insect attack were invariably lower than farmer's estimations of losses, for both cassava and sweet potato. Highest losses observed in cassava products were found in Kwimba, Mtwara and Masasi districts.

4. Insects from cassava and sweet potato products were often the same as those on cereal crops, and cross contamination between crops seems likely. The incidence of the Larger Grain Borer was patchy, even within a village. Many reported occurrences of LGB were found to be due to similar, but less damaging insects. *Sitophilus* spp. were the most commonly observed insects in cassava products, whereas *Rhyzopertha dominica* was more common in sweet potato products. Farmers were aware of losses, and many adopted avoidance strategies. Even heavily damaged material was often utilised, reducing economic losses.

5. It is recommended that further work is carried out on the reduction of insect losses in cassava through better store hygiene and/or insecticide use; the calibration of the visual loss scale for sweet potato, and; some exploratory work to assess the value of promoting starter cultures for better controlled fermentations.

INTRODUCTION

6. Food security is an important issue within Tanzania. The causes of food insecurity have been studied in villages in Mara, Shinyanga and Mwanza regions (CARE International, 1995) where inadequate pest control was one noted constraint. In Tanzania, cassava and sweet potatoes are important food security crops, and will increase in importance with the increase in urbanisation and rural population growth. Dried products are particularly important for household food security in Lake, Coastal and Western Zones and in some regions are also significant products of trade. Price variations are likely with differences in quality. In order to meet future demands for products, an increase in the handling and storage of fresh commodities and dried products will be required.

7. In-store losses of sun-dried cassava and sweet potato products due to infestation by *Prostephanus truncatus,* the Larger Grain Borer (LGB) in Tanzania have been recognised as a problem for some time (Golob and Hodges, 1982; Golob, 1989; Kapinga *et al.* 1995). The socio-economic significance of losses due to LGB in Tanzania has not been evaluated. However, similar research in Togo indicated that, over a six month period, up to 30% weight loss could be recorded for stored cassava (Wright *et al.* 1993). In cases where households rely upon products for income generation or food security, these represent significant losses. In Togo, control strategies based on local practises were identified and tested. Time of harvest was very important, with annual fluctuations of LGB populations occurring with high rainfall periods. Well-constructed mud plastered stores, kept clean and dry, were an effective barrier to infestation.

8. Drying difficulties during the rainy season, leading to excessive mould growth, have been noted in several studies in Tanzania, including Tanga Region and areas supplying Dar es Salaam (Digges *et al.* 1994; Ndunguru *et al.* 1994). Improved sun-drying and storage methods were recommendations from these investigations. Similar observations were noted in an ODA-funded study in Ghana. In this case, slow drying or poor storage during the rainy season led to mycotoxin contamination of products (Wareing, 1993). Additionally, holes caused by insect damage allow entry points for fungi and increase the local moisture content around holes, providing conditions for germination of fungal spores (Dunkel, 1988). Fungal metabolites can also attract insects (Bengtsson *et al.* 1988).

9. Cassava roots harvested during the dry season, when the ground is harder, are more likely to break, and consequently sell at a discount in some areas. Broken roots tend not to be bought by traders and are more likely to be made into *makopa*. *Makopa* made from broken pieces also sells at a discount when compared with whole root *makopa* (Digges *et al.* 1994).

10. There have not been any systematic surveys of losses due to insects and moulds in the major cassava and sweet potato producing areas of the country. In order to establish the extent and nature of post-harvest losses in Tanzania, the current work programme was devised. It was decided to use rapid rural appraisal techniques, to obtain

a 'snapshot' of storage techniques and losses from the main areas where dried cassava or sweet potato products are stored.

METHODS

11. A three person team from Ukiriguru Agricultural Research Institute, Mwanza was joined by an entomologist and a mycologist from NRI to carry out the work. Eight areas of the country had been selected on the basis of high production of either or both of the two crops and their importance to household food security (Figure 1).

12. The work was carried out in two parts. The first stage took place in February and March 1996 to coincide with the rainy season and provided general information on the areas, whilst the second part in November and December 1996 was used to collect numerical data from stores during the dry season. In each area, a number of villages were visited. In Stage 1 a series of informal group interviews were carried out using a checklist (Appendix 1A). Wherever possible two groups, one male and one female, each of approximately 10 people, were interviewed. The meetings lasted about one to one and a half hours each and were followed by visits to individuals' houses to look at examples of storage structures and damaged material.

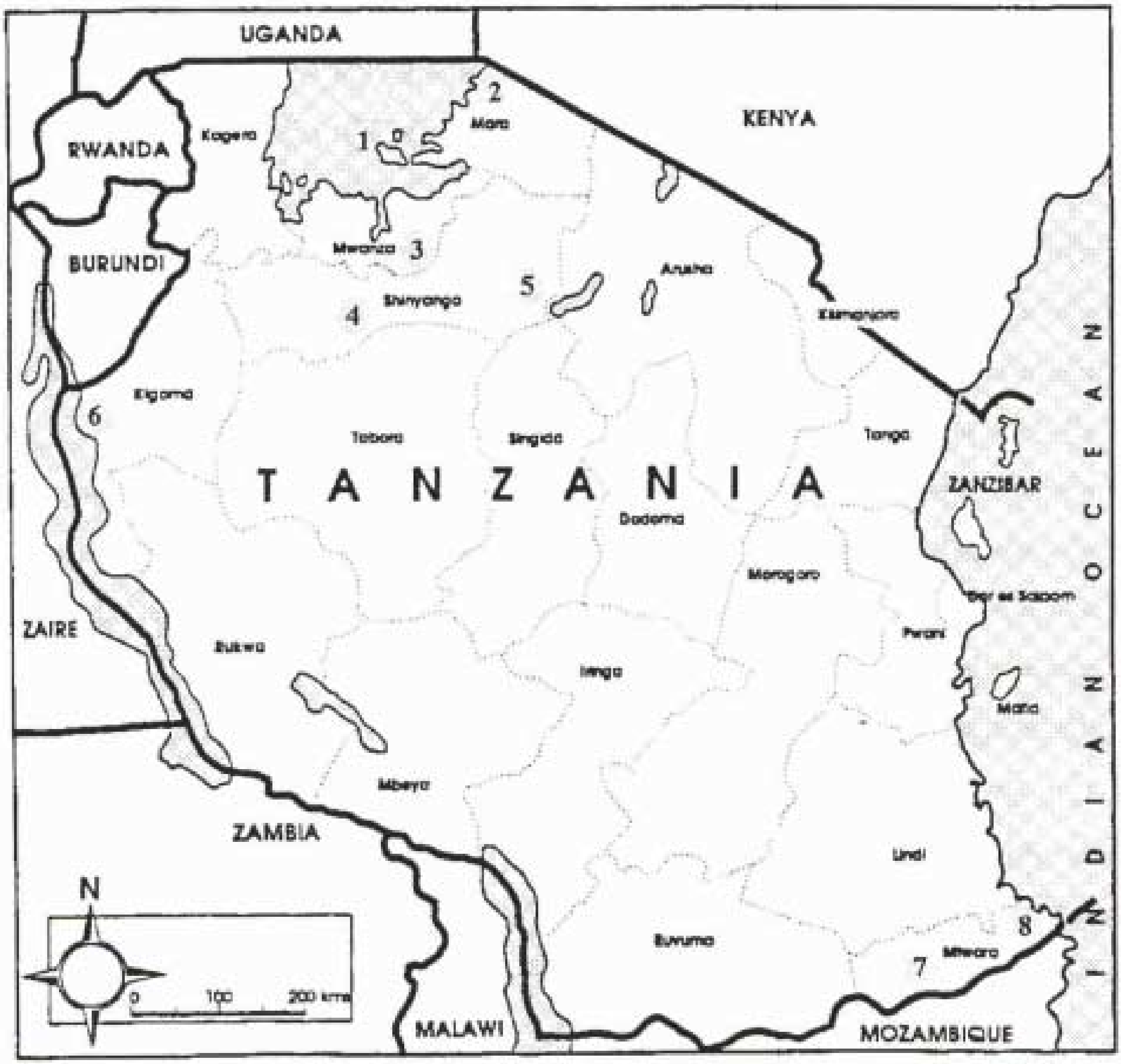
13. In Stage 2, the villages were re-visited so that samples of stored produce could be assessed for damage and these levels related to farmers perceptions of loss and history of storage (Appendix 1B). The villages visited are given in Appendix 2. Householders were asked to remove product from their store in the same way as they would if preparing a meal. This was used as the sample. Infestation was assessed by randomly taking 20 units (chips / slices) of each product from the supplied quantity and ranking according to intensity of insect attack. Cassava was ranked using a photographic visual scale that had originally been developed for use in Togo, West Africa (Compton *et al*, 1992; Wright, 1994) (Figure 2). (Refer to paragraphs 98-100 for further details).

STAGE 1 - RAINY SEASON SURVEY

Results

14. The results from the village level meetings are given, for each of the districts visited, in chronological order. This acts as a record of farmers' statements and so reflects their perceptions and are presented as a synopsis of views from all the villages visited in a given district. It is interesting to note that the information derived from the women and men's groups tallied closely, differing only in pricing information for the marketed proportion of each crop. In cases where information did differ, the information from those responsible for marketing (usually the women) was preferred. When high losses were reported by the farmers, these were not usually borne out by the findings in Stage 2. The significance of these findings is discussed for insect attack and for mould damage in later sections.

Figure 1. Map of Tanzania showing areas surveyed during the cassava and sweet potato storage study



Key:

1. Ukerewe island
2. Tarime district
3. Kwimba district
4. Kahama district
5. Meatu district
6. Kigoma district
7. Masasi district
8. Mtwara district

Ukerewe island

15. Ukerewe is a very large island in the south eastern corner of Lake Victoria. It has a population of some 207,000 all of whom are actively engaged in agriculture, although fishing is also an important activity. Five villages were visited, representing the wetter north and western parts of the island and the drier south and western areas. The four person team was accompanied to all villages by the District Crops Officer, Mr Lweganwa. In each village two meetings were held simultaneously, for the men and the women, except for Murutunguru where a joint meeting was held.

Cassava

16. Cassava is considered to be the most important food crop. No long term storage of cassava, or its products, is practised. The crop is stored short term as a single product - *udaga*, a coarse flour produced via several different techniques. The commonest, which also gives the best quality *udaga*, has the following post-harvest stages:

Peel and sun-dry 1-2 days
↓
Cover with grass, banana leaves or ashes, to allow fermentation to take place, for 2-4 days
↓
Scrape off the fungi
↓
Pound
↓
Sun-dry 1-3 days

17. The drying period varies during the year according to the amount of sunshine. *Udaga* can be stored in sacks, tins or baskets for up to six months. Most farmers only keep it for a two month period. Farmers explained that the *udaga* tends to be made piecemeal, in response to family needs. If it is kept for more than three months insect attack begins. Virtually no evidence of insect infestation was noted in the villages apart from the occasional, very light, presence of *Sitophilus* sp. Should insects occur, the farmers re-dry in the sun or sieve the flour to remove them.

18. Several other, though far less widespread processing techniques, were reported by the farmers. These techniques all involved water rather than air-fermentation and all these methods resulted in an inferior quality *udaga*. The farmers explained that the flour has an unpleasant odour, a poorer taste and a less firm consistency when made into *ugali*. The methods are summarised below.

19. The advantages of these techniques are that they are much less time consuming (removing the need to scrape off the fungi), give a very white *udaga* and require a shorter overall drying period.

Harvest	Harvest	Harvest
↓	↓	↓
Soak (unpeeled) either cut or uncut for 4-7 days	Peel	Peel
	↓	↓
	Cut into thick pieces	Soak whole for 2-3 days
↓	↓	
Peel	Soak for 2-3 days	↓
↓	↓	
Squeeze out water	Squeeze	Squeeze
↓	↓	↓
Pound	Pound	Pound
↓	↓	↓
Sun-dry (2-4 days)	Dry (2-4 days)	Dry (2-4 days)

20. The air fermentation process results in mould growth on the cassava pieces. Farmers noted that normally the moulds are black and these result in the preferred end product. Farmers also said that red, white and yellow moulds can occur, though much more rarely than black moulds. Red moulds appear to be related to poor drying conditions, such as occur during the rainy season (November - February). At these times, if drying after fermentation is not possible, the pounded *udaga* is kept tightly compressed in sacks or tins. If it is kept under these conditions for more than four days, red moulds can occur. Some farmers commented that red moulds were also associated with cassava grown in certain soil types and also if the cassava was kept drying too long before the fermentation stage. *Udaga* can still be made from red moulded cassava but is less preferred having a bitter taste and an odour. Alternatively it can be made into a local brew. White moulded cassava tends to be made into the local brew. A yellow discoloration was sometimes observed on pieces of *udaga* drying in the sun, although this was less common than red or white mould growth. In many cases, an orange discoloration was also observed. There is no word in Swahili for orange; when farmers described red or yellow mould growth, they were often referring to an orange coloured fungus, which was more common than the red or yellow colours, also observed by the team on some samples.

21. Up to a quarter of the cassava crop is marketed. Traders come to the main market, Soko Mjinga in Nansio town, from Mwanza and Mara regions to buy *udaga*. In addition, cassava can still be purchased while still in the field, with the traders agreeing to buy a certain number of rows. *Udaga* made from black moulded cassava fetches the best price. That made from red moulded cassava either sells more slowly or suffers up to a 30% decrease in value. *Udaga* that has been made using the water immersion processes also suffers a small price penalty. In addition, well pounded *udaga* sells faster or at a slightly higher price than that which has larger pieces of cassava remaining. Prices fluctuate during the year with highest prices occurring in the rainy season.

Sweet potato

22. Sweet potato is considered to be the second most important food crop after cassava. There is virtually no storage of sweet potato; the crop is left in the field until needed. Farmers have their fields both on the higher ground and in the low lying paddy rice areas so that sweet potato is available for harvest throughout the year. The roots when freshly harvested and undamaged can be kept in good condition for 7-10 days. Those which are damaged during the harvesting process only last three days. Field problems (insect attack and rotting) are considered serious and damaged roots are thrown away as they are harvested or used as cattle fodder.

23. Villagers said that some farmers, who have a shortage of land, store their sweet potato in holes in the ground which are then covered in soil. This is only suitable for undamaged roots. Sweet potatoes can apparently be kept in this way for six months.

24. Sweet potatoes are marketed in Nansio as well as the mainland markets of Mwanza and Musoma. Roots with signs of insect damage do not command such a good price as undamaged tubers.

25. Although the farmers knew of different storage forms of sweet potato e.g. *michembe* none of them made it. Some of them maintained that their varieties were not suitable for storage in this way.

Ranking of problems

26. When asked what were the biggest problems associated with cassava and sweet potato, the villagers were unanimous that field problems were the main perceived constraint, in particular:

- Cassava - cassava mealybug, white scale, termites, monkeys and mole-rats;

- Sweet potato - leaf miners, mosaic virus, field weevils and monkeys.

<u>**Tarime district**</u>

27. Tarime is a large district on the eastern shore of Lake Victoria. It has a population of some 424,000 for whom agriculture is the main activity. Seven villages were visited, spread throughout the district. The three person team was accompanied to all villages by the District Plant Protection Officer, Mr Kimicho. In each village two meetings were conducted, for the men and the women, except for Mogabiri, Gamasara and Gwitiryo where joint meetings were held.

Cassava

28. Cassava is considered to be the most important food crop. No long term storage of cassava, or its products, is practised. The crop is stored short term, up to four months,

as a single product - *makopa*, which are dried split roots. This is produced in one main way:

Harvest cassava
↓
Peel
↓
Sun-dry 2-3 hours
↓
Cover with banana leaves or place in sack to allow fermentation to take place for 2-3 days, depending on variety (bitter varieties take longer)
↓
Product can then be scraped (if they wish to make *udaga*) to remove fungi or, more normally, left with the fungi on
↓
Sun-dry 3 days (or up to 1 week in rainy season).
(Alternatively if *udaga* is to be produced it is sun dried for a single day, pounded and then further dried for 1-2 days).

29. A variation on this technique was noted whereby after the initial sun-drying for 2-3 hours, the roots are soaked for 4-5 hours and then sun-dried for a further five days. Although this gave very white *makopa*, it was less appreciated because of the amount of water required and the need for large numbers of containers.

30. *Makopa* can be stored in sacks or *vihenge* - large woven basket structures normally mudded on the inside and/or outside walls. Storage is not usually for more than 3 months. Insects, largely *Sitophilus* sp. and *Rhyzopertha*, begin to appear in the *makopa* after this time but are not considered serious. The *vihenge* are apparently better containers than sacks in terms of preventing insect infestation. Should insects occur, the farmers either re-dry it in the sun, sell it, give it to their poultry or make it into local brew.

31. In Luo areas, *udaga* was made using a mixture of fermented and non-fermented material as below.

32. The fermentation process results in mould growth on the cassava pieces. Farmers noted that normally the moulds are black and these give the preferred end product. Farmers also said that yellow and white moulds can occur, though much more rarely than black moulds. 'Yellow' (probably orange) moulds are the result of poor drying conditions, such as occur during the rainy season (November - February). At these times, from half to all the *makopa* produced has yellow moulds associated with it. The *makopa* can still be ground and used to make *ugali* but this is less preferred having a bitter taste, thinner consistency and a bad odour. Alternatively it can be made into a local brew. Many farmers said that the white moulds were only present in the early stages of fermentation and that they were replaced by the black ones as the process

continued. It is possible that the white mould in this case is an immature phase of the black moulds observed.

Harvest
↓
Peel
↓
Sun-dry 2-3 days
↓
Ferment 2-3 days ↘

Harvest fresh cassava and peel ↙

↓
Pound together in equal amounts
↓
Leave covered 1 day
↓
Re-pound
↓
Sun-dry 1-2 days

33. Up to a quarter of the cassava crop is marketed, though normally it is only small amounts. Farmers sell in the local villages as well as in Tarime and Sirari. *Makopa* with black mould commands the best price. Roots showing yellow mould either sells more slowly or suffers up to a 30% decrease in price. Similarly, insect attacked *makopa* can have up to a 40% price decline. If there is very little *makopa* in the market-place, both yellow moulded and insect attacked *makopa* can sell at the full price. Prices can fluctuate widely during the year depending on availability.

34. In two villages, Nyabisaga and Gwitiryo, farmers mentioned that with the use of new bitter varieties some health problems were becoming apparent. Specifically they said that children suffered anaemia type symptoms (blood reduction - "kuishiwa damu") which sometimes led to child death. It was not clear how widespread a problem this was but it should be followed up in the second stage of the project.

Sweet potato

35. Sweet potato is considered to be a relatively minor crop following cassava, maize, sorghum, millet and banana. There is no storage or processing of sweet potato; the crop is left in the field until needed. The roots when freshly harvested and undamaged can be kept in good condition for seven days. Those which are damaged during the harvesting process only last three days before rotting occurs. Field problems (insect attack and rotting) are considered serious and damaged roots are thrown away in the field as they are harvested.

36. Sweet potatoes are marketed locally as well as in Tarime and Sirari. Up to half the crop is sold. Tubers with signs of insect damage do not command such a good price as undamaged tubers. Prices fluctuate by up to 100% throughout the year.

37. Farmers expressed a desire to be taught systems that would allow them to store sweet potatoes for longer periods.

Ranking of problems

38. The major problems associated with cassava and sweet potato, according to the villagers, were field problems, in particular:

- Cassava - mole-rats, cassava mealybug, weevils, lack of drying and marketing facilities, and weeds (particularly *Richardis brasiliensis* and *Dictaria* sp.);

- Sweet potato - mole-rats, field weevils and rotting in the field after delayed harvesting.

Kwimba district

39. Kwimba is a district whose main town, Ngudu, is approximately 90 km south of Mwanza. It lies in a dry zone and the population of 512,000 are all actively engaged in agriculture. Kwimba has recently been split into two smaller districts, Kwimba and Misungwi, but, for the purpose of this study, the old boundaries were used. Six villages were visited by the four person team who were accompanied to all villages by the District Crop Specialist, Mr Makaranga. In each village two meetings were held simultaneously, for the men and the women, except for in Ngula and Nyamilama where joint meetings were held.

Cassava

40. Cassava is the main root crop but is considered less important than maize and also, sometimes, sorghum. The crop is stored short term as *makopa* but storage periods are not as long as they used to be. The main season for makopa production is the dry season (June - September) although it continues to be made piecemeal throughout the year. It is made using the following stages:

Harvest
↓
Peel
↓
Sun-dry 2-3 days
↓
Ferment under wet or dry sacks, grass or cassava peelings for 2-4 days
↓
Sun-dry up to 1 week

The *makopa* is often quickly washed to remove moulds before storage.

41. The *makopa* is stored in sacks, *vihenge* or in the house either on raised platforms or directly on the floor. Cassava is usually marketed as *makopa* because traders find it easier to transport. Therefore, even though *udaga* is preferred to *makopa* for making *ugali*, and suffers less insect attack, *makopa* often commands a higher price in the market-place. *Makopa* is sold on quite a large scale with ¼ to ¾ of the crop going to market, either in local markets or in Ngudu. *Makopa* prices can show a four-fold difference in price throughout the year, with prices highest in December - January. If *udaga* is being made, the cassava is scraped following the fermentation process, pounded and then dried for 1-2 days. *Udaga* is not stored but used immediately for consumption.

42. *Makopa* can be stored for 2-3 months before insect damage starts to appear. It is not usually kept for more than six months because of insect attack (prior to the arrival of Larger Grain Borer, LGB, *makopa* could be kept for over a year). The main insect pests are LGB and *Sitophilus* spp. and these occur every year. In previous years, farmers used Actellic Super (permethrin + pirimiphos methyl) to control insects successfully. Farmers have stopped using it because recent batches have proved ineffective. Some farmers re-dry their *makopa* if insects occur to reduce the infestation. Lightly damaged material is still consumed but with heavy damage it is either thrown away or used to make local brew. There is either no market for insect damaged material or the price can drop to half the normal price.

43. During the fermentation process black, white and red moulds can occur. *Ugali* made from the black moulded *makopa* is the preferred end product. Red moulds are a function of poor drying and so occur more frequently during the rainy season when ¼ to ¾ of the crop can show red moulding. This is still consumed although it results in a poor consistency *ugali*.

Sweet potato

44. Sweet potato is a relatively minor crop after maize, cassava and sorghum, although it has an important role to play in the dry season. Normally only a small proportion of the crop is marketed, and this in the form of *michembe* - thin slices of sun dried sweet potato. Sweet potatoes are eaten fresh from the field from February until the beginning of the dry season (June). June till August is the peak period for *michembe* production and may represent half of the total sweet potato crop.

45. Sun-drying before peeling allows the sweet potato to develop a certain rubberiness that allows thin slices to be made without disintegration. Some farmers also maintain that it helps to increase the sweetness of the final product. The peel is often thrown on the fields as a fertiliser. It is not usually given to livestock because it is said to cause bloating and diarrhoea. *Michembe* is made in the following way:

Harvest
↓
Sun-dry 2-3 days
↓
Peel
↓
Slice thinly
↓
Sun-dry 3-4 days
↓
Stored in sacks or *vihenge*

46. Insect infestation becomes apparent after 2-3 months and the *michembe* can not usually be kept longer than six months. Farmers said the main problems were LGB, weevils and moth larvae, but this could not be confirmed by the team since virtually no *michembe* was in store at the time of the visit. There are no control techniques to prevent insects. Farmers used to use Actellic Super but, as a result of poor control recently, have now stopped its use. Lightly damaged *michembe* is still eaten, but heavily infested material is thrown away, burnt or sometimes given to goats and donkeys. Infested material is said to have a bitter taste and a bad smell.

47. Although it was not made in the district, some of the farmers knew about a different technique for storing sweet potato that is common in the Tabora and Shinyanga areas. This gives a product known as *matoborwa*. This is made by harvesting, peeling, and cooking completely (up to an hour), then sliced and sun dried for up to six days. This is made particularly in the period of June - August. Although this gives a very durable product, which is sweeter than *michembe*, it is very expensive in terms of both firewood and water requirements.

Ranking of problems

48. Cassava - post-harvest insect infestation is the most serious constraint according to the farmers. Some field problems were also mentioned such as cassava mealybug, scale, and rats but these were of much less importance.

49. Sweet potato - post-harvest problems due to insects were also the main problem in sweet potatoes. However it should be noted that one of the main reasons for making *michembe* is that the roots can not be left in the field over the dry season because weevil attack leads to rotting. In fact, farmers often prefer to eat the fresh root and so this problem of field deterioration also needs to be addressed.

Kigoma district

50. Kigoma district lies on the eastern shore of Lake Tanganyika in western Tanzania. It has a population of 437,000 who are mainly small scale farmers. Five

villages were visited by the five person team who were accompanied to all villages by the District Plant Protection Officer, Mr Lusendela. In each village two meetings were held simultaneously, for the men and the women.

Cassava

51. Cassava is the major staple crop along with maize. Cassava is marketed, although only in small amounts, in its fresh form and also as dried pieces or as flour. The importance of the processed products in terms of marketing varied with village. Most is sold locally or in Kigoma. Fresh cassava is sold in bundles at a constant price throughout the year (100 - 200 TSh depending on bundle size). The price of flour varies from 30-60 TSh for a half kilo. The flour is derived from two distinct cassava products which are made using water and air-fermentation processes. The water-fermented product, *kivunde*, is made as follows:

Harvest
↓
Peel
↓
Placed in oil drum of water 2-4 days (longer in cool periods)
↓
Sun-dry 3-5 days
↓
Store

52. This gives a very white product which is highly appreciated. However, it requires a lot of water and the oil drums are expensive (8000 TSh). *Kivunde* tends to be made in the dry season (May - September) because it is essential that the large pieces can be dried without the risk of being re-wetted by rain, which would cause the product to rot.

53. The second product, *nyangi* is essentially the same as the *makopa* described from other areas. It is made in the following way:

Harvest and peel
↓
Sun-dry 2-3 days
↓
Ferment under grass or banana leaves for 3 days
↓
Sun-dry 4-5 days
↓
Scrape off fungi
↓
Store

54. Both these products are pounded before consumption. *Kivunde* is the favoured product commanding a 15 - 50% price premium in the market over *nyangi*. There is very little storage of the processed product. Generally, the farmers practice piecemeal harvesting and processing to meet their immediate needs. Longer term storage only occurs from the beginning of the dry season when farmers hold back some of their stock in anticipation of market prices rising. The products are kept in sacks, on the floor, woven baskets or on a raised platform (*kichanja*) over the kitchen fire. Although this last storage method was considered effective in reducing insect attack, the storage capacity tends to be limited.

55. *Kivunde* and *nyangi* can be stored for up to six months. Insects (*Sitophilus* sp. and possibly Larger Grain Borer) start infesting the material after three months; farmers suggested that *nyangi* is the less attacked of the two. Lightly infested material is still eaten, heavily infested stock is thrown away, given to the goats or sold at a very reduced price to make local brew. Heavy infestation can give the products a bitter taste.

56. During *nyangi* production, black, red and white moulds are seen. Black and red both give good *ugali* (though the red derived product is less thick). White moulds give a thin porridge with a poor taste. The red moulds occur particularly in September, during the high humidity period which precedes the rainy season. Although black derived *ugali* is normally considered to be best, at this time red moulded *nyangi* may be preferred because under these climatic conditions, *nyangi* with black moulds may also show internal black moulding which leads to bitter tasting *ugali*.

57. Kigoma differed from the previously visited districts in appearing to have a relatively well developed local trader sector. This seemed to have three levels of activity:

- Stall holders who bought cassava brought to the market by farmers. They then mill the cassava themselves and sell it the same day.

- As above, but with the traders being prepared to store the flour for up to three months.

- Traders who visit the villages to buy cassava, keep it in small warehouses and mill it as required in the marketplace. The stored cassava (as *nyangi* or *kivunde*) can be kept for at least five months.

58. The extent, if any, of trader problems was not established and could form the basis for future studies.

Sweet potato

59. Sweet potato is considered to be the third food crop after maize and cassava. It is sold locally and in Kigoma, with up to ¾ of the crop being marketed, though this varies widely by village. Sweet potatoes are sold in piles which have a constant price throughout the year (200 TSh) but with the size of the bundle varying with degree of

scarcity. Prices are highest (i.e. bundles are smallest in January - February). Signs of insect attack reduce the selling price by 25%.

60. In lakeside areas and those areas where farmers have access to both hillsides and low lying areas, sweet potatoes can be planted to allow harvesting throughout the year. Normally however, harvesting is between February and June. Sweet potatoes left in the field after this time are prone to weevil attack and subsequent rotting. Damaged sweet potatoes are left in the field.

61. All farmers said that they would like to learn a technique that would allow them to harvest their crop in June and transform it into a suitable storage form. This would allow them to sell their crop during the dry season when prices are higher (July - October).

Ranking of problems

62. Cassava - the main problems were considered to be field problems especially cassava mealybug, mole rats and baboons. In one village, Kagera, cassava cultivation had almost been abandoned because of mealybug attack. However, storage can be considered a problem in some villages in as much as the villagers treat the field as their cassava store. One of the reasons why cassava is not harvested in bigger quantities is that the farmers cannot store their produce because of the risk of insect attack. Field storage is therefore a risk avoidance technique.

63. Sweet potato - the main problems were again those associated with field attack particularly baboons, mole rats and weevils.

Mtwara region

64. Mtwara region is in the south east of Tanzania bordering both Mozambique and Malawi. The area is among the highest cassava producing regions in the country and has a population of 550,000 most of them engaged in agriculture, with some fishing. Surveys were carried out in both Mtwara and Masasi districts by members of the Ukiriguru team accompanied by a staff member of Naliendele Research Station.

Mtwara district

65. Four villages selected from Mtwara urban and rural districts were visited by the team. The three person team were accompanied by the District Crops Officer, Mr Linguya.

Cassava

66. Cassava is the major food crop in the district, followed by maize, sorghum and rice. The crop occupies ¾ of the total farmed area.

67. Both fresh roots and *makopa* are marketed. Prices of fresh roots range from 50 TSh per root to 2000-2500 TSh per *kitenga* (equivalent to approx. 50 kg). These prices are constant throughout the year, except during the month of Ramadan when they increase. Highest prices for *makopa* are realised in March/April (3000-5000 TSh per 70 kg bag); and they are lowest in July-September (2000-2500 TSh per bag), due to a lot of processing being done during this period. *Makopa* is sold at 25 TSh per kg in co-operatives, although co-operatives were not buying at the time of the survey (March).

68. Cassava is processed mainly into *makopa* and *chinyanya*. *Makopa* is the commonest processed product and is usually stored for future use. *Chinyanya* is only processed during periods of food shortage; otherwise it is a rare product. No storage of *chinyanya* is practised. The processing stages of the two products are outlined below.

Makopa:

Harvest
↓
Peel and slice (if necessary)
↓
Sun-dry (on platform in the field)
↓
Store

69. After processing, *makopa* is stored on *kichanja* over the kitchen fire, on the floor in the house or in sacks. The stored product suffers severe insect infestation during storage. In about 6-8 months there is total loss of the produce. The most common insect species responsible for this damage are: LGB, *Sitophilus* spp., *Tribolium* spp. and *Rhyzopertha* spp. Rats are another storage problem, but their effect is not as severe.

70. Heavily infested *makopa* is fed to chicken and goats. There is also a price reduction for such products. A bag of infested *makopa* sells for as little as 1500 TSh.

Harvest
↓
Peel
↙ ↘

Chinyanya 1:

Slice/crush into smaller pieces
↓
Sun-dry for a few hours
↓
Pound into flour

Chinyanya 2:

Soak 1-2 days
↓
Crush
↓
Sun-dry 1 day
↓
Pound into flour

71. Mould problems occur only when processing is affected by rain or when the stored product is re-wetted, for example due to store leakage. Mouldy products are not liked and so normally the mould is scraped off before utilisation.

Ranking of problems

72. The major problems, for cassava post-harvest, mentioned by farmers in order of importance are: insect damage in store, rotting of roots, wild animals (pigs, rats and monkeys) and health disorders due to the consumption of insufficiently processed cassava products.

Masasi district

73. Masasi is in Mtwara region. It has a population of 374,000 who are mostly engaged in agriculture. The team of three people was accompanied by the Division Extension Officer, Mr Kwingwa. Four villages were visited and a single group interview was conducted in each. The groups were dominated by men with very few women taking part.

Cassava

74. Cassava is the most important food and cash crop in the district, followed by maize, rice and sorghum. Cassava occupies 75% of the total arable land of Masasi.

75. Three processing techniques are practised in the district to make *makopa*, *chinyanya* and *chiloweke*. The latter two, which are very similar, are not sold but are made during food shortages because they are quick methods for obtaining food. The processes are given below.

76. Cassava is marketed fresh or as *makopa*, and is sold to individual traders, unions and individual consumers. For fresh cassava the price is 50-100 TSh per bundle of 3-4 roots (approximately ½-1 kg). Seasonal price variations occur in *makopa*. In October to January when the product is scarce, the price is between 6000-8000 TSh for a 70 kg bag, while in February to September the price is between 3000-4000 TSh/bag. However, the union purchase *makopa* at the price of 70 TSh/kg and the price is constant for the whole year.

77. Sales account for a quarter of the total cassava produced. Cassava is stored as *makopa* over the fireplace, in sacks or *vihenge* and may be kept for up to 1 year. The limiting factor in storage was insect attack. Main pests were reported, by the farmers, to be LGB (very serious), *Sitophilus* spp., *Rhyzopertha* and *Tribolium* spp. In the presence of these insect pests, storage is limited to 3-6 months and after six months the damage is almost 100%. The insect pests are serious the whole year around. Pest attack (and mould damage) reduces the price of *makopa* in the market. No control strategies for insects are promoted or practised in the district. Seriously damaged *makopa* is used for

soft drinks or animal feeds although farmers mentioned that in a food shortage period it may be used for human consumption.

Makopa:

Harvest
↓
Peel
↓
Sun-dry 8-14 days
↓
Store

Chinyanya:

Harvest
↓
Peel
↓
Soak in water 2-7 days
↓
Sun-dry 2 days
↓
Pound
↓
Store

Chiloweke:

Harvest
↓
Soak in water 3-5 days
(with or without peels)
↓
Peel (if soaked with peels)
↓
Sun-dry 1-2 days
↓
Mill
↓
Store

78. Mould damage occurs in cold weather i.e. when the product is stored before proper drying or when the product is stored in a leaking roof. The moulds are black and farmers normally scrape off the mould from the product before consumption.

Ranking of problems

79. Farmers mentioned field rotting and storage pests as their major problems, followed by cassava mealybug, moulds, grasshoppers and inadequate storage facilities.

IMPLICATIONS OF INSECT AND MOULD FINDINGS FOR FUTURE WORK

Insect findings

80. In this, the first stage of the project, field work was carried out during the wet season. In practical terms this meant that very little cassava or sweet potato was in store and so, largely, insect identifications have been made based on farmer descriptions. However, in most villages some samples were seen allowing these tentative identifications to be confirmed.

81. The most widespread insects in cassava and its products were *Sitophilus* sp. In addition, there was evidence of *Rhyzopertha* and *Tribolium* in some samples seen. These tended to be most severe in stores with poor hygiene or where different crops were stored together allowing the species to cross infest. *Prostephanus* was the only insect that gave rise to unacceptably high losses (or potentially high losses in stocks that were sold or exhausted quickly in order to avoid infestation). *Prostephanus* was only confirmed in Kwimba although farmers said it was also present in Kigoma (though none were seen by the team).

82. In sweet potato, very few samples were available to the team. It appeared that *Sitophilus* was the dominant pest although *Prostephanus* was reported by farmers in Kwimba to be a problem. In Stage 2, the dry season survey, the nature of insect attack and the causative species will be established.

Mould findings

83. It should be noted that there is no Swahili word for orange and in fact the 'yellow' moulds described in Tarime are the same moulds which were called 'red' in Ukerewe - they are in fact orange coloured. Field evidence gathered by the team indicates that there were also true red and yellow moulds present on some samples, although these were much less common than the orange coloured mould. It is probably safe to assume that most references to 'red' or 'yellow' really refer to the orange mould.

84. Microscopic observation showed that the black moulds were either *Rhizopus* sp., or *Mucor* sp., rarely *Alternaria* sp. or *Cladosporium* sp. *Rhizopus* was more common than *Mucor*. They were found on *makopa* and *udaga*, and formed the dominant flora on most products. The orange mould was *Neurospora sitophila*, commonly associated with *Rhizopus*; like *Rhizopus*, growing under conditions of high water activity, such as is found in freshly harvested products. The white mould was probably *Geotrichum candidum*, a yeast-like fungus that has an easily-fragmented mycelial form. The occurrence of this latter fungus would partly explain the observation that products covered with the white growth gave a sweet, fermented smell, though not that they also seemed bitter. Some of the true red moulds observed on products from Ukerewe by the team were probably *Fusarium* sp.; a microconidial form was observed on some samples. It is likely that some of the 'white' fungi noted on some products was the immature stage of *Rhizopus*, because it does appear white, up to one days growth. The only area where true red growth was seen was on Ukerewe island. The true yellow mould was actually a

mycelial fungus that caused a yellow discoloration of starch grains; the fungus itself was not yellow. Since it did not sporulate, it was not possible to determine its identity.

85. None of the commonly observed fungi are significant producers of mycotoxins; they can produce secondary metabolites, but these are not particularly toxic. However, it should be noted that other fungi, capable of producing mycotoxins, are often associated with these more common fungi, but they are more difficult to detect, because of overgrowth by other fungi. There was some evidence of *Aspergillus versicolor* and *Penicillium* sp. in samples from Ujiji market that had been stored for up to 3 months. Both of these fungi can produce mycotoxins. Previous work (Wareing, 1993) indicates that mycotoxins can be produced in slowly dried cassava products; *makopa* would therefore seem to be most at risk.

86. Fungal problems mainly appear to be a quality issue; holding the harvested cassava too long before fermentation, or drying delays post-fermentation, can result in the growth of undesirable moulds. For example, a red colour can be associated with a bitter tasting end product. The fermentation that leads to a black colour seems to be preferred by most people, although others prefer an orange or white colour. It is difficult to discern if they sometimes mean the colour of the flour made from the *udaga* or *makopa*, or the mould itself. Evidence from other research (Essers *et al.* 1995) indicates that *Neurospora sitophila* followed by *Rhizopus stolonifer* and *R. oryzae* are the most efficient moulds in causing cellular breakdown and thus initiating maximum removal of cyanide from roots. Processor perceptions are therefore generally in line with this evidence.

Implications

87. The implications of the findings relate mainly to the needs of the second stage of the work programme.

88. It is recommended that Ukerewe island need not be re-visited in Stage 2 since farmers' current strategies allow them to avoid any particular post-harvest problems and the farmers themselves do not regard post-harvest as a priority area.

89. The team recommends that Tarime be re-visited since child health problems related to the use of bitter varieties warrants further investigation. Since cassava toxicity is essentially a result of shortcomings in processing procedures, there is obvious potential for assistance, once the nature of the problem has been made clear. In addition, the team could establish the potential and real demand for introducing techniques for storing sweet potatoes. There is, however, some doubt over the potential for adoption by farmers, since sweet potato is a relatively minor crop in the area.

90. Kwimba undoubtedly suffered the greatest insect problems. This was due in large part to the presence of the Larger Grain Borer. Losses are significant after three months of storage and it is recommended that Kwimba is re-visited to try and quantify these losses. However, perhaps of greater significance than the currently experienced losses is the fact that farmers can no longer store their cassava for as long as was

previously possible. The project should therefore work towards solutions that would allow farmers to extend their storage period to its previous length of up to one year. It is also recommended that both Shinyanga and Tabora districts be visited (both of which are known LGB areas) to determine whether similar problems exist there as well. Tabora is also the centre of *matoborwa* (boiled and dried sweet potato) which was not encountered by the team in the other areas visited. This will allow the team to assess its suitability for adoption in other areas of Tanzania.

91. Kigoma district showed limited justification for a return visit. Neither insects nor moulds posed any particular problems for farmers who tend to store for short periods only. However, the team recommend that Kigoma be included in Stage 2 because there is evidence to suggest that there is a significant trader population, dealing in cassava products, that may store for up to five months and who may suffer problems of insect infestation. The return visit should concentrate its activities mainly on this trader sector. Some farmers expressed interest in storage techniques for sweet potato. As in Tarime, this should be investigated with the reservation that farmers were again aware of potential techniques without having adopted them of their own volition.

92. The team also recommends that Mtwara needs to be revisited in Stage 2, to quantify losses. It was observed that losses of *makopa* are so significant that farmers cannot store the product for more than six months. In this area, cassava is a major food and commercial crop, and farmers and traders need to be able to store the processed product for long periods.

STAGE 2 - DRY SEASON SURVEY

93. The second stage of the work programme was carried out during November 1996. It was designed to provide a quantitative assessment of storage losses in cassava and sweet potato to complement the descriptive first stage, carried out during the rainy season. Information was gathered both from secondary sources (district and regional offices and post-harvest projects) and from farmers themselves.

94. It should be noted that the farmers in the whole of the Lake Zone of Tanzania complained of a drought during the 1995/96 growing season. In fact, as shown in Table 1, what is meant is that the rains finished earlier than normal, during the critical March - May period, so that many plants were affected as they reached maturity.

Table 1. Monthly rainfall at Ukiriguru observation point (Lake Zone) for the growing seasons 1993-96.

Month	Rainfall / mm		
	1993/94	1994/95	1995/96
July	0.0	0.0	2.6
August	0.0	40.3	0.0
September	6.7	0.0	10.4
October	65.3	84.4	105.3
November	45.6	239.8	101.5
December	24.0	168.3	107.0
January	166.2	99.0	93.0
February	69.1	95.2	100.7
March	170.8	178.1	191.8
April	99.0	137.7	47.5
May	59.0	68.7	46.6
June	7.2	42.4	0.5

96. This resulted in an extremely poor sweet potato, and to a lesser extent cassava, harvest so that in many villages it was rare to find sweet potato products. In these cases, the survey team specifically visited those households with products and assumed losses were indicative of those suffered by the wider community in more normal years. They also talked to farmers who had recently finished their stocks to gain a better understanding of storage management practices.

Methods

97. Wherever possible the same villages as were visited during Stage 1 were re-visited (Appendix 2B). Following the first village, where all team members worked together to become accustomed to the procedures, the team split into two small groups to undertake household investigations. Each team was accompanied by a village member to allow introductions to be made in the five households visited. Households were selected using a transect walk technique. Starting from the village centre the two teams worked

in opposite directions. Where practicable (householders were at home and they stored dried cassava / sweet potato) discussions were held at every third house (or more if houses were tight-packed). Interviewers asked questions based on a pre-arranged checklist (Appendix 1B).

98. In the Southern zone the team consisted of the two Natural Resources Institute staff members, Mr Jeremiah (Ukiriguru) and Mr Sadala (Naliendele). For the Lake zone studies Mr Sadala was replaced by Mr Msabaha (Ukiriguru). Due to time constraints, Kigoma was not re-visited, as had previously been proposed. In addition, Kahama and Meatu districts were included to obtain more information relating to drier areas.

99. A sample of the product was taken from the store, by the householder, in the same way as would be used for taking a quantity for consumption, for assessment. For each product 20 units (chips / slices) were taken at random from the supplied quantity and ranked according to intensity of insect attack.

100. Cassava was ranked using a photographic visual scale that had originally been developed for use in Togo, West Africa (Compton *et al*, 1992; Wright, 1994) (Figure 2). Originally the scale was divided into five classes depending on the density of holes on the chip's surfaces. However, it became clear that, particularly at lower levels of infestation, chips were showing attack levels intermediate between classes 1 and 2. Therefore, for the purposes of this study an intermediate class, 1A, was added. The nominal value of losses corresponding to these visual classes were:

Class 1	0%
Class 1A	3.6%
Class 2	7.2%
Class 3	22.2%
Class 4	29.5%
Class 5	42.2%

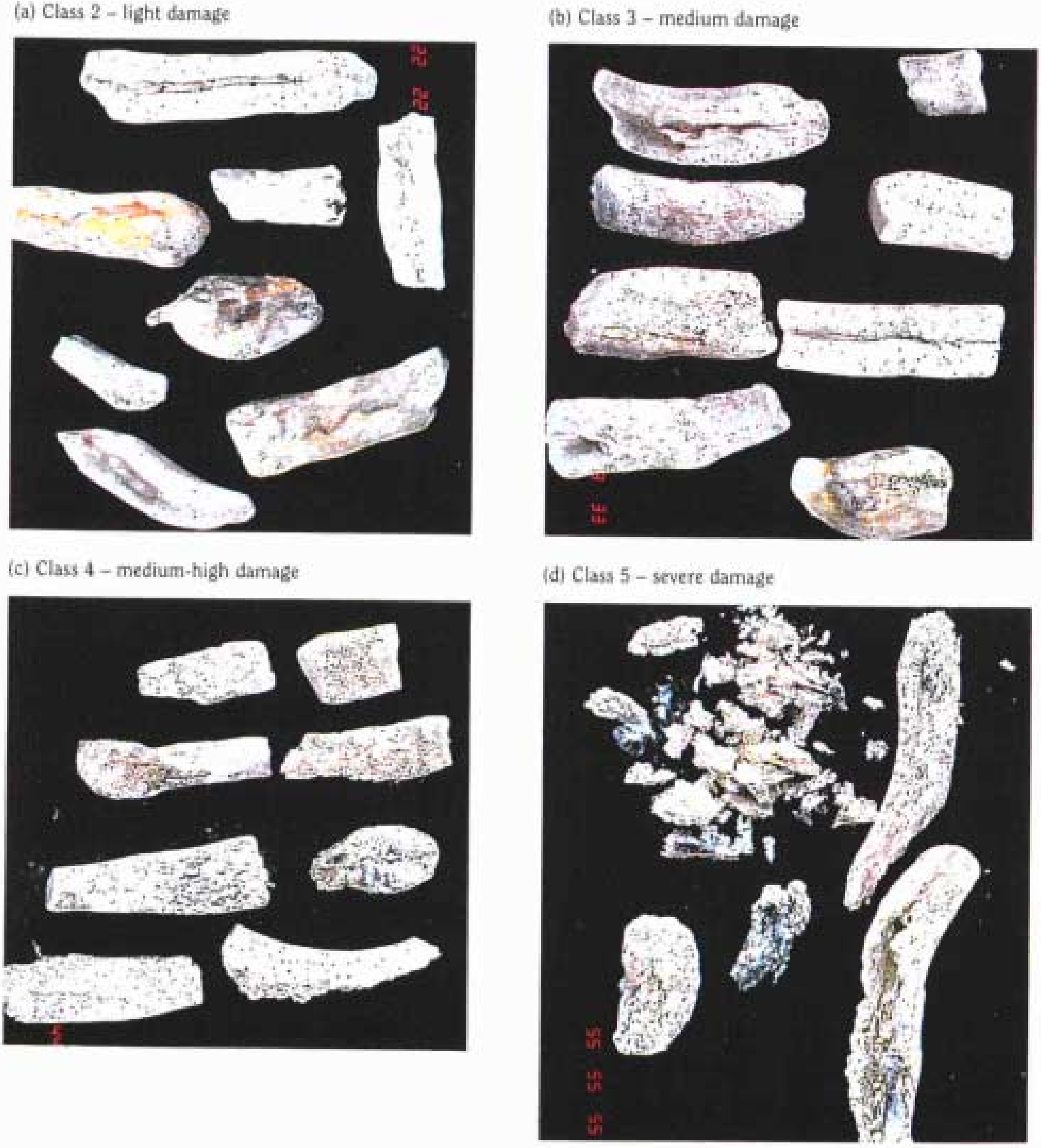
The 20 chips were sorted into their respective classes and the mean loss for that sample could be calculated using:

$$\frac{\text{(No. of chips in Class 1 x 0\%) + (No. in Class 1A x 3.6)......+ (No. in Class 5 x 42.2)}}{20}$$

101. It should be noted that these loss figures were determined for cassava stored as chips in West Africa where, although the climate and storage structures are not dissimilar, the pest spectrum is different as are the cassava varieties used. Therefore, although the figures give a reasonable indication of the magnitude of losses incurred, they can not be considered as definitive until further research indicates the relationship between Togolese and Tanzanian losses, or the scale is re-calibrated for the Tanzanian situation.

102. Sweet potato losses were estimated using an adaptation of the cassava system. Chips were graded into the same nominal classes as the cassava by comparison of the

Figure 2. Visual damage scale for cassava (Class 1, undamaged - not shown)



Source: Compton *et al*, 1992

density of holes on the sweet potato chip's surface. Representative samples of chips from each of these classes were taken to the Natural Resources Institute, where the proportion of the surface area missing, as a result of the holes, was assessed using an image analyser. Since in many cases the holes pass through the chip entirely, the percentage reduction in surface area was considered equivalent to the percentage weight loss of the chip. This relationship does not hold true when insects bore within the chips which is the case in Classes 2 and 3. However, it indicates the minimum loss experienced. Losses recorded during the survey are therefore almost certainly under-estimates but without a full calibration procedure using 'weigh-in weigh-out' of artificially infested samples, no other measures exist. Nominal losses corresponding to the different classes were:

Class 1	0%
Class 1A	0.6%
Class 2	1.2%
Class 3	2.1%
Class 4	5.3%
Class 5	not present

103. Full data sets for the grading of the farmer' samples are given in Appendix 3 (cassava) and 4 (sweet potato).

RESULTS - Southern Zone

Masasi district

104. The four villages that had been visited in March were re-visited. The four person team was accompanied by the Divisional Extension officer, Mr Kwingwa. The main characteristics of the storage system for the district are given in Table 2.

Table 2. Descriptive indicators of the cassava storage system in Masasi district (10 farmers / village)

Village	No. using dari	No. using smoking	Mean no. of sacks	Mean no. of months in store	Indicative wt. loss of samples %
Chisegu	10	2	8.7	2.4	2.8
Mpekeso	10	3	5.6	2.4	1.2
Nahawara	10	0	9.4	2.5	2.3
Mlundelunde	7	3	6.2	2.7	2.9

105. The farmers generally harvested cassava in August to September. The farmers store cassava as *makopa* which is kept in the *dari*. A few of the farmers positioned their *dari* over the kitchen fire. Those farmers practising this technique feel it has some benefits as the smoke dries and hardens the chips, whilst those who don't use it say that the colour change leads to unattractive-looking and bitter *ugali*. Cassava is the major

food source for the villagers and as a result the bulk of the cassava is grown for home consumption. Some of the farmers, who have harvested more than they need, use the cassava as payment to agricultural labourers for land preparation and weeding activities.

106. Several interesting points arose from discussions with the individual farmers. Farmers in Masasi frequently cited field problems, and in particular cassava mealybug, as being the limiting factor in producing sufficient cassava. Storage factors often ranked second. This confirms the views expressed by farmers in the Stage 1 survey.

107. Typically, farmers stored their cassava until February-April. Since the following cassava crop is not harvested until about August, the farmers then rely on their secondary crops such as maize and sorghum. They also buy in *makopa* and other food as necessary.

Mtwara district

108. The four villages that had been visited in March were re-visited. The four person team was accompanied by the District Crops officer, Mr Linguya. The main characteristics of the storage system for the district are given in Table 3.

109. The farmers tended to harvest during August and store the processed crop as *makopa* in the *dari* over the kitchen fire. Cassava is the most important food crop and nearly all the crop is destined for home consumption.

Table 3. Descriptive indicators of the cassava storage system in Mtwara district (10 farmers / village)

Village	No. using dari	No. using smoking	Mean no. of sacks	Mean no. of months in store	Indicative wt. loss of samples %
Msijute	10	9	2.4	3.2	1.7
Maranje	10	8	5.3	3.1	3.5
Nanguruwe	10	8	7.9	2.8	2.3
Kiromba	10	9	9.6	2.6	7.1

110. As in Stage 1, farmers stated that storage problems were very serious and affected the food storage strategy used. Most farmers were storing until March - May by which time the cassava is heavily infested. This damaged product is still eaten by the farmers. Once the stocks were exhausted, farmers bought *makopa*, that comes from surrounding areas, in the local market or maize flour. Some relied on other crops such as maize, sorghum and pumpkins to tide them through. However, many of the farmers whose stocks ran out after this time in store, still had cassava in the field. They return to the fields and harvest in a piecemeal fashion and process the cassava into *chinyanya*. This is a less preferred product but allows the farmers to avoid having their entire stock attacked in store.

General observations from the Southern Zone (Masasi and Mtwara)

111. Several features of the districts are common, and can usefully be considered together. Although farmers expressed concerns over the level of insect losses in store, they also made clear that rats were as serious, if not worse, as a storage pest and evidence of rodent damage was evident in many of the stores visited, particularly in Mtwara district. Some farmers practised chemical control for rats but trap use was more usual.

112. Farmers were aware that different varieties were susceptible to differing levels of insect attack. For example, the sweet local variety Mureteta was considered to be softer and more insect-prone than the harder sweet variety Nachinyaya. The efficiency of store cleaning prior to loading with the new cassava crop varied enormously and seemed to play a major part in determining the lag period before onset of insect attack. Some farmers replace the flooring of the *dari* (made from mats, sorghum stalks or banana leaves) on a yearly basis as well as sweeping thoroughly amongst the supporting beams. In contrast, others merely bang the matting to remove the worst of the remains from the previous crop, thereby leaving a potential source of immediate re-infestation of the new crop. *Makopa* was almost invariably stored alone in the dari. Where maize is grown it is stored outside the house on a vertical drying rack (*msuta*). The maize frequently showed evidence of *Sitophilus* damage. Sorghum was occasionally found and was stored in beehive-shaped stores made of concentric rings of woven grass or in small barrels made from bark. The major pests seen were *Rhyzopertha* and *Sitophilus*.

113. In stored *makopa*, *Dinoderus* spp. were the predominant pest. Some other species were also present in varying numbers at some of the households and included *Sitophilus*, *Araecurus fasciculatus*, *Thaneroclerus buqueti* (a predator of other storage insects), and the Larger Grain Borer. LGB was only found rarely, supporting the earlier findings of Riwa (1994) whose survey of the region found limited evidence of its occurrence. This is unsurprising, since LGB was only first recorded from Mtwara in 1994 (Mallya and Nyakunga, 1996).

114. Many farmers observed that a significant increase in insect damage coincided with the onset of the first rains (although they were aware that infestation could begin during the drying process in the field), and that cassava also softened as the humidity rose. Farmers living near to the sea sometimes maintained that the salt air made their cassava more susceptible; this may be a related phenomenon if the salt on the chips' surface causes more water uptake and therefore surface softening. Initial insect attack tends to be on the outer, peeled surface first, and then as infestation progresses, onto the inner, cut surface. This may reflect density or nutritional differences within the root. Most of the farmers were prepared to eat *makopa* that had become highly damaged, although they complained that this resulted in a much softer, and therefore less satisfying, *ugali*. In addition, and particularly in Masasi district, farmers used the damaged material to make *togwa* (a non-alcoholic drink) or local spirit.

115. Products were not deliberately mould fermented in the Southern Zone. Mould growth occurred or increased with the onset of the rains, or if rain occurred during drying. Farmers preferred not to have mould growth but despite this, still consumed the

cassava, after scraping off the mould before cooking. Mould was therefore not considered to be a constraining factor but, it should be noted that , if mould growth occurred, it is more likely to be from opportunist fungi, some of which could produce mycotoxins.

RESULTS - Lake Zone

Kahama district

116. Kahama district had not been visited in the first phase of the survey but was included in this phase because it is normally a large producer of cassava and sweet potato. Kahama was divided in 1995 to create two new, smaller, districts; Kahama and Bukombe. For the purposes of this report the old district boundaries were used.

117. Five villages were visited but data are presented for only four because in the fifth (Igunda) almost no farmers were storing cassava or sweet potato products. The four person team was accompanied by either Mr Suwi or Mr Matongo the District Agro-mechanisation officers. The district suffered from poor rains in the 1995/96 season and consequently the sweet potato harvest was extremely poor. District officials were not able to give the team suggestions for suitable villages to work in, with the result that the team were obliged to work with the minority of farmers who appeared to be storing the processed products.

Cassava

118. The main characteristics of the storage system are given in Table 4. The small sample sizes reflects the difficulty the team had in locating farmers with a stored product. Maize is the most important staple food crop in the district. Cassava is usually placed second or third in importance behind rice or sorghum, depending on the area, with sweet potato lying fourth. The cassava is stored almost exclusively as *makopa*, although a few farmers stored it as roughly pounded coarse flour (*udaga*). Most cassava production is for home consumption. The main period for *makopa* production is in July - September during the dry season. The product is then stored in a wide variety of containers including sacks, *kihenge*, loose on the floor, bark barrels (*vilindo*) and in outside cribs (*ikunguku*). Most farmers did not practice any form of insect control measures. Of those that did, one used sun-drying to force out the insects, several used Actellic Super, and several said they made small chips, which helped to reduce the infestation.

119. On average, the samples examined had been in store for slightly more than two months. Most of the farmers were only anticipating keeping their stocks in store for about 4-5 months, until January, when they would either harvest fresh cassava stocks from their fields for processing, turn to their stored maize, or buy in maize and / or cassava. The period from January - March is when food stocks are at their lowest, however most farmers said they had enough stored crops to see then through this time. Ordinarily the cassava and maize are mixed together when making *ugali* which allows both crops to last longer.

Table 4. Descriptive indicators of the cassava storage system in Kahama district (n = number of farmers sampled / village)

Village	n =	Mean no. of sacks	Mean no. of months in store	Indicative wt. loss of samples %
Ngogwa	6	2.7	2.2	0.2
Mwabomba	10	2.1	2.1	3.2
Nyambubi	9	4.7	2.0	0.5
Ihulike	11	2.6	2.2	0.7

120. The majority of the farmers practised piecemeal harvesting of their cassava. They explained that this helped to spread the workload but was also an effective way of avoiding post-harvest insect problems. In effect, the farmers were using their fields as stores.

121. The main storage problems were due to insect infestation. Although some LGB and other members of the family Bostrichidae were present in the samples seen, the dominant pest at this stage of the season appeared to be *Sitophilus*. Rodents and moulds were not considered to be important. Since the production process involves fermentation by deliberately encouraging mould growth, producers accepted mould growth and its associated discoloration. Undesirable effects on flavour and odour were noted, but people would often still consume the products. There was some evidence of the growth of potentially mycotoxigenic fungi. It was noted that a *makopa* sample from one farmer had a heavy infestation with *Aspergillus parasiticus*, which was reported to give the *ugali* made from it a bad smell and a bitter taste. In this case, the mould was scraped off before consumption. *A. parasiticus* can produce the carcinogen aflatoxin under certain conditions. A sample of the product was analysed at NRI for its aflatoxin content. NRI standard operating procedure was used (Dell *et al.*, 1990), after grinding the sample. The sample was analysed in duplicate. Results gave 20.2 µg/kg aflatoxin B_1, and 34.8 µg/kg total aflatoxins. All four aflatoxins were detected. These levels are high enough to represent a danger to human health.

Sweet potato

122. Due to the rains finishing early in March 1996, the sweet potato crop was extremely poor. As an indication of this, in one village, Ihulike, for those farmers we found with sweet potato, average yields were 1-2 bags. Ebong (1994) who had worked in the same village in a more typical year found farmers harvested a mean of 5.4 bags. So despite the fact that Kahama district is ordinarily a big producer of sweet potato, the team found it very difficult to locate any farmers with the stored product. The main processed form was *michembe* which, even after the 4-5 months for which it had typically been in store, showed very low levels of loss (maximum of 0.3%).

123. The main insects responsible for damage were *Sitophilus* and *Dinoderus*. Even among those farmers who had stocks, the amount remaining was very small and was not generally expected to last beyond December. Generally, no insect control measures are

used although one household did practice regular sun-drying to force out the insects. In this case, *Sitophilus* was the dominant insect pest.

124. Some farmers had also produced *matoborwa*. This was particularly the case with farmers who had had a good harvest and would therefore need to store for longer. *Matoborwa* is a harder product which is more insect resistant than *michembe* but has extra costs involved (firewood, water and labour). Farmers sometimes mix the two products in order to reduce the losses in the *michembe*, or alternatively lay *matoborwa* on top of the *michembe*, in store, to form a protective layer. All samples of *matoborwa* inspected were undamaged, with no visible evidence of insect attack. Both products were stored in a variety of containers including bark barrels, *kihenge* and sacks.

Other crops

125. Maize was frequently found being stored at the homestead at the same time as cassava and sweet potato products. This is normally harvested in April / May so had already been in store for 6-7 months. Some farmers were shelling and treating with insecticide but most kept their maize as cobs in outside cribs, bark barrels or *kihenge*. Cobbed maize showed some damage, largely due to *Sitophilus* with some LGB, but damage levels were still acceptably low. Farmers were generally aware that the insects attacking maize were also the ones infesting cassava and sweet potato products but felt they could do little about it.

Meatu district

126. Meatu district had not been visited in the first phase of the survey but was included in this phase in order to get more information on sweet potato processing and losses. Four villages were selected to give a good geographical spread. The survey team were accompanied in the field by Mr Senzota, the District Extension Officer.

127. Meatu district is split into two distinct agro-ecological zones. The southern half is extremely dry whilst the northern half is more hilly and receives better rainfall. The district, as with all the districts visited in the Lake Zone of Tanzania, experienced poor rains during the 1995/96 season with the result that sweet potato harvests were extremely poor. The only exception was in Bukundi, in the extreme south, where farmers used river water to irrigate their crops. The result was that very little sweet potato product was left in store by the time the survey team arrived. The data presented here is therefore from a biased sample of those farmers who actually had product left. However, these results should still give an indication of the extent of the losses that could be expected in a normal year. Hart (1991) in a survey of 30 households in Meatu and Maswa found that 50% of respondents exhausted their stocks in the period of December - February and this can be considered to be more typical. Anania (1993) also states that the typical storage period for sweet potato chips was six months in the three villages in which he worked.

128. Sweet potato is the second or third crop following maize and / or sorghum. Most of the sweet potato is harvested and processed in May - July. *Michembe* is the major

product although most households also produce *matoborwa*. The products are stored mixed together and typically stored in *kihenge* often on top of a second crop such as shelled maize or groundnuts. Almost all the sweet potato produced is for home consumption, although villagers in Bukundi also market their crop. Although sweet potato can be consumed throughout the day, it is typically used as the breakfast meal. Main features of the crop storage system are given in Table 5. Most of the farmers had exhausted their stocks by the time the survey team arrived, however in normal years farmers said they would expect to keep their product for up to 8 months, until February. After this period they rely on maize and sorghum stocks, either stored or bought in, to see them through until the next harvests.

Table 5. Descriptive indicators of the sweet potato storage system in Meatu district (n = number of farmers sampled / village)

Village	n =	No. storing in *kihenge*	Mean no. of sacks	Mean no. of months in store	Indicative wt. loss of samples %
Bukundi	10	5	16	3.6	0.1
Malwilo	10	7	8.4	5.0	0.2
Sakasaka	9	5	2.9	4.8	0.2
Lubiga	9	6	2.1	5.3	0.3

129. Storage losses in *michembe* were very low. Some farmers complained of rat problems but generally insects were considered to be the principal cause of losses. Losses, where seen, were due to *Rhyzopertha*, *Dinoderus* and *Sitophilus* with some moth damage also being noted. Hart (1991) noted that 77% of farmer complaints were as a result of insect damage including 'dumuzi' - the local name for LGB. In our survey, LGB was not found in this area and we assume that Hart's statement was due to insect mis-identification by the farmers (as was also the case in our sample population). Farmers explained that they kept the two sweet potato products mixed because, apart from producing the preferred tasting food, it also helped to reduce insect infestation. Fungi were not a problem in any of the samples. Produce that does become heavily infested is re-dried in the sun to reduce insect numbers or is fed to livestock. *Matoborwa* was never found to be damaged.

Kwimba district

130. During the first phase of the project, six villages had been visited in Kwimba district. For the second phase, four were re-visited. The survey team were accompanied, as before, by Mr Makaranga, the District Crops Officer. Due to the drought of the 1995/96 season only limited quantities of sweet potato products were in store during the team's visit. Maize is the main staple crop in the district followed by cassava or sorghum and finally sweet potato or rice. When other crops are exhausted, farmers rely on their own maize stocks, fresh cassava from their fields or products bought in the market to see them through to the next season.

Cassava

131. Main features of the cassava storage system are given in Table 6. Cassava is normally stored as *makopa* although some of the farmers stored it as a coarse pounded product (*udaga*). The bulk of the commodity was destined for home consumption.

Table 6. Descriptive indicators of the cassava storage system in Kwimba district (10 farmers sampled / village)

Village	No. storing in sacks	Mean no. of sacks	Mean no. of months in store	Indicative wt. loss of samples %
Nyamilama	10	3.2	3.5	2.1
Kishili	9	1.6	1.2	0.8
Walla	8	2.0	1.1	0.0
Kilyaboya	9	1.7	3.0	2.2

132. In this district the commonest cassava harvesting practice was to harvest in a piecemeal fashion. For those villagers harvesting in July - August, as well as those who were drying *makopa* at the time of the team's visit, stocks were expected to be finished by December. At this time the villagers anticipated returning to the fields to harvest and prepare a new batch. Reasons given for this practice included labour and storage space constraints but primarily as a necessary pest avoidance strategy. Farmers maintained that insect infestation normally becomes extremely heavy after 3-4 months and that leaving the crop in the field was the best solution to the problem. Some farmers explained that they would prefer to harvest the whole crop at the same time but the threat of insect attack made this impossible. Some of the farmers had used Actellic Super on their *makopa* with variable success. Where insect damage was found it was due to LGB, *Rhyzopertha* and *Sitophilus*. A few *Tenebroides mauritanicus* were also found; this is both a predatory species as well as feeding on the commodity. When cassava did become heavily damaged it was either thrown away or made into a local brew. Fungi were not a source of storage losses.

Sweet potato

133. Very few farmers were found with sweet potato products. From this limited sample it was seen that farmers processed the sweet potato into *michembe* only. Most harvesting was in June - July and stocks were being exhausted at the time of the team's visit (although in years with better rainfall the harvest would be greater and hence the storage period longer). The *michembe* was normally stored in sacks. Some farmers used Actellic Super to control insects with good results and one farmer was using maize cob ash to little effect. Insect damage, in the few samples seen, was due to *Dinoderus* and *Sitophilus* with a few *Lophocateres pusillus* present. Fungi and rodents were not considered constraints during storage.

Tarime district

134. In the first phase of this project, seven villages had been visited in Tarime district. For the second phase, four villages were re-visited as well as Mwera Hospital. The survey team were accompanied by Ms Mlemwa, the district Nutrition Officer. Only cassava products (*udaga*) were observed in store since although sweet potato was being grown, none was processed for storage.

135. Piecemeal harvesting was the commonest practice with farmers harvesting enough for 1-3 weeks consumption. This is typically 1-2 tins on each occasion and so stored stocks are always low (Table 7). The reasons for not harvesting more are primarily labour constraints as the processing of cassava is only done by women, lack of storage facilities and because piecemeal harvesting is the traditional practice. The few farmers storing *makopa* use sacks. Insect damage is not experienced because the storage period is so short. In some cases farmers said they observed insects from sorghum and maize attacking cassava products. Cassava and sorghum are the main food crops; maize is grown as a cash crop.

Table 7. Descriptive indicators of the cassava storage system in Tarime district (n = number of farmers sampled / village)

Village	n =	Main store type	Mean no. of tins	Mean no. of weeks in store	Indicative wt. loss of samples %
Gwitiryo	10	Tins	2.5	1-1	0.0
Nyabisaga	10	Tins	4.0	1	0.0
Gamasara	9	Tins	1.7	1	0.0
Kiterere	10	Tins	2.0	1-2	0.0

Health problems

136. The team re-visited those villages where cassava toxicity problems had been reported in Stage 1 as leading to anaemia and child mortality. Farmers explained that the problem was serious, especially during the period when consumption of cassava products is high. There are occasions, for example, when farmers consume porridge made from cassava flour and also *ugali* made solely from cassava (rather than mixed with sorghum which is the normal practice). The problems only occur with bitter varieties e.g. Lumala. In Gamasara and Kiterere, farmers also complained that diarrhoea was brought on by this variety and, as a result, many farmers have abandoned this variety.

137. In order to get an idea of how widespread this phenomenon is, the team visited Mwera, the main hospital in the district, to determine the number of anaemia cases reported from the Tarime highlands. For the period of July-November 1996, the number of cases were as follows:

July	41 cases
August	31 cases
September	23 cases
October	17 cases
November	20 cases

138. It should be stressed that, unfortunately, the cause of these anaemia cases is not recorded and so can not be assumed to be as a result of cassava consumption.

GENERAL DISCUSSION

Cassava

Levels of loss

139. It is clear from all survey areas that losses estimated by the team were always less than those perceived by the villagers in Stage 1. Losses calculated using the methodology described in paragraphs 99-102 are based on actual weight losses in the chips / roots showing particular densities of holes. The method relies on the roots being present and so if, for example, a farmer has thrown away roots which were considered unfit for consumption, this loss technique will lead to under-estimates. However, there is no evidence to suggest that this took place to any significant degree and so the estimates are considered to be valid. Table 8 shows mean losses in cassava, by month, for the Southern and Lake zones.

Table 8. Summary of cassava losses in survey areas, by month.

Months in store *	Southern zone		Lake zone**	
	% loss	No. of samples	% loss	No. of samples
1	2.5	18	2.6	11
2	2.6	10	2.4	15
3	3.0	25	1.0	14
4	4.4	12	2.1	9
5	4.3	4	4.6	3
6	1.6	1	0.5	2

* Data showing variable number of months e.g. 1-2 has been excluded.

** Loss data from Tarime has been excluded since storage periods were so short.

140. Insect derived weight losses in cassava tend to be below 5%, certainly for the first four months of storage. However, it is acknowledged that losses are not uniform and that individual farmers suffer much higher losses than the average suggests (see Appendix 3). The figures presented in Table 8 do not take consumption patterns into consideration. Since in most cases up to half of the storage period had already passed, and therefore ¼-½ of the stock had already been consumed, real losses i.e. loss as a proportion of the total amount originally stored, are lower still. Maximum storage periods vary from region to region, with cassava stored for longer in the Southern Zone. Many farmers in Mtwara district were storing for up to eight months, from August through to the following May. However, the amount remaining in May is likely to be small and so losses suffered by this quantity have little impact on overall losses during the complete storage season.

Loss avoidance strategies and their effectiveness

141. In the Lake Zone it appears that insects are not typically a serious problem post-harvest in terms of the losses they cause. The exception to this is Kwimba district. Here it is apparent that, although losses were low at the time of the team's visit, LGB has become so well established that farmers have altered their storage practices to avoid its

attack. In this case, the effect of the insect is not to inflict losses *per se* but rather to prevent farmers from practising their favoured storage strategies. Farmers are forced into piecemeal harvesting and storage for relatively short periods of time, as opposed to the traditional system of harvesting their whole stock and storing it for up to one year. Whilst piecemeal harvesting is a reasonable pest avoidance strategy in the short-term, it is only appropriate whilst there is no land pressure, allowing farmers to leave their crops in the ground.

142. In the past, when over-population leading to land pressure became a problem for the people of the Lake Zone, the population migrated to other areas (Meertens *et al.*, 1995). Migration is no longer an option; most areas of available land have already been settled, apart from certain areas of Meatu District. The Maswa Game Reserve limits expansion to the east; westwards, the population density is already high. Population density is rising, and land pressure is becoming a problem within some parts of the Lake Zone, particularly Kwimba district and the area around Ukiriguru. It is therefore important to develop a storage and pest control strategy that will, once again, allow farmers to store their harvest for longer periods. This needs to be in place before land pressure becomes too extreme.

143. In the Lake Zone, there are usually two exceptionally dry years in ten, with droughts more likely in the semi-arid southern part, around Meatu. In this respect, the current findings, despite being carried out in a year characterised by drought, are not altogether atypical.

144. Food insecurity is seen as a widespread, and chronic, problem rather than an acute one. Household food studies have indicated that children aged from six months to eight years may receive only 67% of their total energy requirements during the post-harvest period, but that during the lean season, this may fall to 50% (Lorri and Kavishe, 1990). Cassava, as a food security crop, extends the storage period of grains, with food grains lasting 2-3 months longer than in those households not growing it (Lorri and Kavishe, 1990; Seenappa, 1987).

145. In the south of the country, food security is regarded as having sufficient cassava to last until new grain crops are harvested (Missano *et al.*, 1994). Food shortages were judged to have occurred when households had to harvest thinner, more immature roots, typically during December-March. In Mtwara region in particular, the majority of households are food insecure (Kingamkono, 1989). As yet, LGB has not yet become firmly established in the Southern Zone. As it does, it is safe to assume that cassava losses in store will become more severe than a present.

Mould damage

146. Fermentative mould growth is encouraged in the production of cassava products from the Lake Zone. In this area of Tanzania, moulds are perceived more as a quality issue; certain types giving a better taste to the end product. The fungi encouraged to grow during the initial fermentation are high water activity, soft-rotting organisms. Because these fungi were encouraged to grow, it is less likely that toxigenic moulds

would be able to grow and produce mycotoxins at any later stage. *Aspergillus parasiticus* and aflatoxins were found in one sample of *makopa* which had experienced drying delays during preparation. If products are prepared during the rainy season, then there is a possibility that toxigenic fungi could grow. However, field evidence from the first stage visit, conducted during the rainy season, suggest that this is very uncommon. Areas which experienced heavy rain almost daily avoided the problem by producing *udaga*, which dries more quickly than *makopa*.

147. Losses due to moulds were economic ones, rather than physical. Red, white and yellow coloured products either sold for up to 30% less than black or orange products, or were used for local brew. It is difficult to discern if the production of local brew from cassava products represents a loss, because it was produced, sold and consumed in many areas. If food is scarce, even those products that are not preferred are sold or eaten; perceived losses are therefore reduced in times of scarcity.

148. In the Southern Zone, although cassava products were not deliberately fermented with fungi, any mould growth that did occur was not seen as loss causing. Mouldy products were sold for less than non-mouldy ones, but farmers certainly did not see moulds as a priority issue.

149. For deliberately fermented products, there is little that can be done to encourage the growth of preferred moulds. Some farmers already use previously fermented products as starter cultures, to ensure the fermentation proceeds well. This practice should be encouraged. From the limited evidence available, there does not seem to be sufficient justification in conducting a mycotoxin survey of cassava products. Fermented products do not appear to be under a great risk of mycotoxin contamination. The situation seems different to that within Ghana, where rainy season products were at some risk of mycotoxin contamination (Wareing, 1993). Work on moulds should be limited to an encouragement to use starter cultures for fermentation which could be promoted through the Extension services. There is no evidence that fungi increase within store, since most products appeared to be well-dried.

Sweet potato

Levels of loss

150. Sweet potato is a quick growing crop, maturing within 3-4 months. It normally grows within the rainy season, acting as a useful food security crop, providing food when supplies from the previous season have finished and before the next main harvest period. An early end to the rains is therefore very significant, shortening the growing season and reducing yields.

151. Estimates for sweet potato showed, without exception, that losses were low for *michembe* (<1%) and negligible for *matoborwa*. However, the team has some doubts as to the accuracy of the calibration used for the sweet potato, with a suggestion that the technique under-estimates losses, and it is strongly recommended that a more detailed calibration is undertaken. In all cases, losses were lower for sweet potato products than

for cassava, over comparable storage periods. Moulds were rarely seen on sweet potato products and were never a cause of loss. Sweet potato products dried quickly and generally remained too dry for mould growth. There is no justification in carrying out any more work on mould losses in sweet potato products.

Loss avoidance strategies

152. Some farmers mixed *matoborwa* in with the *michembe*, or placed a layer of *matoborwa* on top of *michembe*. This was claimed to reduce the level of attack in the more susceptible *michembe*. No other loss avoidance strategies were practised for sweet potato products.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Cassava

153. In the Southern zone, insects are not considered to be a major constraint, although this may change as LGB becomes established. In the Lake zone, LGB is the most damaging pest of cassava and it is recommended that attention is given to improving store management in order to reduce its impact. In particular, store hygiene appears to play a significant role in determining subsequent levels of insect attack and should therefore be more actively promoted by the Extension services.

154. The use of insecticides (particularly Actellic Super dust) on cassava is already being practised by some farmers. Previous studies have already shown that the similar insecticide deltamethrin is effective in controlling LGB in cassava chips (Wright, 1994). It is recommended that studies be carried out to determine the effectiveness of Actellic Super under field conditions and, if appropriate, to prepare guidelines for their use.

155. Fungi do not appear to be a constraint on cassava storage. There is therefore no justification for any work on fungal aspects of storage. There is some scope, however for improving the outcome of air-fermentation by using simple starter cultures to ensure that the most appropriate (preferred) moulds develop. The Extension services are best placed to promote these techniques. This could be supported by a study of the fermentation process itself to allow greater prediction of the moulds that may form under different conditions.

156. Rodents are locally important but can, in part be controlled by good store hygiene, store maintenance and use of traps.

Sweet potato

157. This first appraisal of sweet potato losses suggests that these tend to be low. This may, in part, be due to the poor yields resulting from the drought and the consequent early exhaustion of stocks. However, there is an urgent need to re-calibrate the sweet potato visual scale under more rigorous conditions (through comparing measured changes in weight with visual appearance of the *michembe* slices) after which a more considered evaluation could be made.

158. Although there is some evidence of rodent attack, neither rodents nor fungi are constraints to sweet potato storage and no further work needs be done on them.

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Glossary and acronyms

Chinyanya - a crushed, dried cassava product; usually for immediate use.

Chiloweke - soaked in water, crushed and then dried; usually for immediate use.

Dari - attic space in a house, often over the open fire, in which crops may be stored.

Dumuzi - local name for LGB (q.v.).

Ikunguku - maize crib used for both drying and storage.

Kichanja - raised platform for sun-drying or for drying over the kitchen fire.

Kihenge (pl. = vihenge) - traditional storage structures in the form of large woven baskets. These may be mudded on the inside and/or outside surfaces.

Kilindo (pl. = vilindo) - storage barrel made from tree bark.

Kitenga - a local measure, equivalent to approximately 50 kg.

Kivunde - water-fermented cassava roots prepared as a storage product.

LGB - Larger Grain Borer (*Prostephanus truncatus*).

Makopa - air-fermented cassava roots prepared as a storage product.

Matoborwa - boiled and sun-dried sweet potato.

Michembe - sun-dried thin slices of sweet potato.

Msuta - vertical rack used for drying maize cobs.

Nyangi - a regional name for makopa (q.v.).

Togwa - a non alcoholic drink made from cassava.

TSh - Tanzanian shilling.

Udaga - pounded makopa (q.v.) or kivunde (q.v.).

Ugali - a stiff porridge which forms a staple of the Tanzanian diet. It may be prepared from maize, sorghum or cassava flours either individually or as a mixture.

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Appendix 1A. Checklist of questions for village surveys (Stage 1)

Objective - to determine the nature and extent of losses in stored cassava and sweet potato.

The following is a list of possible topics, to be used as a guide, rather than as a formal questionnaire.

General points for each crop:

What is the importance of sweet potato / cassava to the overall family food budget?

Are either of these crops marketed; if so, where and what proportion of crop?

How are they stored, are there different storage forms? If so, what proportion of the crop are transformed into each type?

Why do farmers keep more than one storage form of a crop?

What are the processes involved in producing the different end products?

How long are the crops stored (which months) and in what kind of containers? Is this constant throughout the year?

In which month do you process most of your crop?

Are there differences in 'costs' related to each transformation type?

Are there differences in nature of attack for each transformation type?

Insect specific:

What are the major insects involved?

Does the farmer consider them to be a problem?

What is done with insect damaged material?

Does insect damage result in an economic penalty in the market-place? How much?

What does the farmer do to prevent infestation (including traditional practices)?

Are these techniques successful?

Do the extension services / neighbours etc. suggest other control measures?

Are insect problems the same every year? If not when was the last bad year and why was it different?

At what stage during storage do insect problems become apparent?

Fungal specific:

How do you dry your produce? How long does it take to dry (rainy and dry season)?

Do they experience any difficulties with harvesting and / or drying their produce?

Are there times of the year when mould problems are more pronounced?

Does well dried produce ever become mouldy?

Would you eat mouldy produce? How do they distinguish between the moulds they encourage and others?

Describe consumption patterns with regard to mouldy cassava - how much; how often?

Do you ever intentionally allow produce to become mouldy?

What colour moulds do you see on your produce? (by transformation type)

Is it possible to remove moulds from the produce? How?

Does the presence of mould effect the marketability of your produce? Is this constant throughout the year?

Do you sell more mouldy or non-mouldy produce?

Final question:

What are the biggest problems faced for each of the two crops? These can be either pre- and/or post-harvest.

Appendix 1B. Checklist of questions for household surveys (Stage 2).

In a non-formal manner address the points given below:

- Establish the importance of the two crops to household food security.
- Determine seasonality of importance.
- Ask for perceived problems.
- At what stage does insect attack become apparent?
- Determine quantity originally stored and how long stocks will last for.
- Determine consumption patterns (and sale patterns if appropriate).
- Describe the storage system used - storage structure, management procedures, control techniques used etc.
- What do farmers do with damaged product?
- What do farmers do when the products run out?

Visually inspect 20 units of commodity (chips / slices etc.)

- How many are insect damaged?
- What is the intensity of attack?

Appendix 2A. Village meetings held - Stage 1.

District	Village	Numbers of participants	
		Men	Women
Ukerewe island	Hamkoko	8-11	10
18-19 February	Muhala	18+	5-16
	Kagunguli	9	9
	Murutunguru	4	8
	Nakamwa	18+	8
Tarime	Mogabiri	4	3
21-23 February	Nyamwigura	12	10
	Nyantira	10	9
	Nyabisaga	13+	10+
		(farmers from 3 villages)	
	Gwitiryo	25+	7
	Gamasara	10+	1
	Kiterere	15+	4
Kwimba	Walla	14	7
24-28 February	Kishili	14	7
	Ishingisha	12	9
	Ngula	5	5
	Nyamilama	14	4
	Kilyaboya	7	7
	Misasi market		
Kigoma	Mwakizega	14	7
2-4 March	Simbo	20	7
	Kagera	12	10
	Kalalangabo	8	18
	Mgaraganza	26+	14+
	Ujiji and Mwanga (Kigoma) markets		
Mtwara	Msijute	20	0
12-17 March	Nanguruwe	16	0
	Maranje	35	6
	Kiromba	45+	7
Masasi	Nahawara	30	0
18-21 March	Mlundelunde	15	0
	Mpekeso	9	2
	Chisegu	14	0

Appendix 2B. Villages visited during Stage 2.

District	Village
Masasi 11-12 November	Nahawara Mlundelunde Mpekeso Chisegu
Mtwara 13-15 November	Msijute Nanguruwe Maranje Kilomba
Mwanza Regional Plant Protection Office 18 November	
Tanzanian - German IPM Project, Shinyanga 19 November	
Kahama 20-23 November	Igunda Ngogwa Mwabomba Nyambubi Ihulike
Meatu 25-27 November	Bukundi Malwilo Sakasaka Lubiga
Kwimba 28-30 November	Walla Kishili Nyamilama Kilyaboya
Hungumalwa and Ngudu markets	
Tarime 16-21 December	Nyabisaga Gwitiryo Gamasara Kiterere

Appendix 3. Grading scores of cassava chips from farmers' stores - November 1996

NORTHERN ZONE - Kahama district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Ngogwa 1	20						<1
2	20						3
3	20						1
4	20						3
5	15	5					2
6	20						4
Mean for each rank	19.2	0.8	0.0	0.0	0.0	0.0	
Mean loss =	0.2						

Mwabomba 1	17	3					2
2	3	15	2				1
3	20						2
4	20						2
5	20						1
6	8	12					3
7	12	6	2				1
8	3	13	3	1			3
9	0	0	7	8	5		2
10	16	4					4
Mean for each rank	11.9	5.3	1.4	0.9	0.5	0.0	
Mean loss =	3.2						

Nyambubi 1	18	2				-	3
2	16	4					2
3	20						4
4	20						?
5	15	5					1
6	14	5	1				2
7	15	4	1				3
8	20						<1
9	20						<1
Mean for each rank	17.6	2.2	0.2	0.0	0.0	0.0	
Mean loss =	0.5						

Ihulike 1	20						3
2	17	3					3
3	20						4
4	20						<1
5	20						<1
6	20						1
7	0	14	5	1			2
8	16	4					3
9	18	2					1
10	15	5					2
11	18	2					2
Mean for each rank	15.1	2.5	0.5	0.1	0.0	0.0	
Mean loss =	0.7						

NORTHERN ZONE - Kwimba district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Nyamilama 1	7	4	9				4
2	20						3
3	19	1					3
4	17	3					1
5	18	2					3
6	2	5	5	5	3		5
7	20						4
8	11	8	1				3
9	18	2					4
10	15	5					5
Mean for each rank	14.7	3.0	1.5	0.5	0.3	0.0	
Mean loss =	2.1						

Kishili 1	20						<1
2	20						<1
3	20						<1
4	14	4	2				1
5	20						1
6	1	15	4				2
7	20						<1
8	20						<1
9	20						2
10	7	10	3				4
Mean for each rank	16.2	2.9	0.9	0.0	0.0	0.0	
Mean loss =	0.8					-	

Walla 1	20						<1
2	20						1
3	20						<1
4	20						<1
5	18	2					5
6	20						<1
7	20						2
8	20						<1
9	20						<1
10	20						<1
Mean for each rank	19.8	0.2	0.0	0.0	0.0	0.0	
Mean loss =	0.0						

Kilyaboya 1	20						<1
2	12	5	3				3
3	12	2	6				2
4	20						<1
5	17	2	1				2
6	20						6
7	0	4	10	5	1		4
8	15	5					6
Mean for each rank	14.5	2.3	2.5	0.6	0.1	0.0	
Mean loss =	2.2						

NORTHERN ZONE - Tarime district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Gwitiryo 1	20						<1
2	20						<1
3	20						<1
4	20						<1
5	20						<1
6	20						<1
7	20						<1
8	20						<1
9	20						<1
10	20						<1
Mean for each rank	20.0	0.0	0.0	0.0	0.0	0.0	
Mean loss =	0.0						

Nyabisaga 1	20						<1
2	20						<1
3	20						<1
4	20						<1
5	20						<1
6	20						<1
7	20						<1
8	20						<1
9	20						<1
10	20						<1
Mean for each rank	20.0	0.0	0.0	0.0	0.0	0.0	
Mean loss =	0.0						

Gamasara 1	20						<1
2	20						<1
3	20						<1
4	20						<1
5	20						<1
6	20						<1
7	20						<1
8	20						<1
9	20						<1
Mean for each rank	20.0	0.0	0.0	0.0	0.0	0.0	
Mean loss =	0.0						

Kiterere 1	20						<1
2	20						<1
3	20						<1
4	20						<1
5	20						<1
6	20						<1
7	20						<1
8	20						<1
9	20						<1
10	20						<1
Mean for each rank	20.0	0.0	0.0	0.0	0.0	0.0	
Mean loss =	0.0						

SOUTHERN ZONE - Masasi district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Chisegu 1	20						3
2	6	7	7				3
3	4	4	5	7			3
4	7	7	6				3
5	19	1					1
6	11	5	4				1
7	19		1				3
8	18	1	1				2
9	17	2	1				1
10	8	4	4	4			3-4
Mean for each rank	10.9	3.1	2.9	1.1	0	0	
Mean loss =	2.8						

Mpekeso 1	19	1					3-4
2	20						1
3	7	7	6				1-2
4	20						3
5	10	4	4	2			3-4
6	20						1
7	20						3
8	18	1	1				3
9	15	3	2				3
10	13	4	3				1
Mean for each rank	16.2	2	1.6	0.2	0	0	
Mean loss =	1.2						

Nahawara 1	19	1					3-4
2	12	5	3				4-5
3	17	2	1				4
4	0	5	6	5	4		3
5	20						2
6	20						1
7	20						1
8	8	1	10	1			2
9	19	1					1
10	17	3					3
Mean for each rank	15.2	1.8	2	0.6	0.4	0	
Mean loss =	2.3						

M'lunde 1	12	4	4				3
2	14	6					1
3	10	6	4				2
4	20						1
5	20						<1
6	15	5					3-4
7	13		7				2-3
8	0	10	10				5
9	0	5	11	4			3
10	1	16	1	2			5
Mean for each rank	10.5	5.2	3.7	0.6	0	0	
Mean loss =	2.9						

SOUTHERN ZONE - Mtwara district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Msijute 1	14	4	2				2
2	18	1	1				5
3	12	6	2				3
4	20						3
5	8	8	4				4
6	6	13	1				4
7	6	14					4
8	17	3					1
9	7	10	3				4
10	13	6	1				2
Mean for each rank	12.1	6.5	1.4	0	0	0	
Mean loss =	1.7						

Maranje 1	11	4	5				4
2	4	6	10				3
3	4	10	6				4
4	20						1-2
5	8	5	7				1
6	0	8	12				5
7	13	6	1				3
8	3	8	7	2			2
9	7	11	2				3
10	1	14	5				4
Mean for each rank	7.1	7.2	5.5	0.2	0	0	
Mean loss =	3.5					-	

Nanguruwe 1	10	6	4				4
2	4	10	5	1			2
3	15	5					3
4	13	7					3
5	5	11	3	1			4
6	17	3					2
7	9	8	3				1
8	2	16	2				3
9	14	6					3
10	12	8					3
Mean for each rank	10.1	8	1.7	0.2	0	0	
Mean loss =	2.3						

Kiromba 1	0	2	14	4			1
2	7	8	5				2
3	13	5	2				6
4	0	5	15				3
5	20						1
6	0	10	9	1			1
7	1	12	7				3
8	10	7	3				4
9	0	1	8	10	1		1
10	0	0	2	16	2		4
Mean for each rank	5.1	5	6.5	3.1	0.3	0	
Mean loss =	7.1						

Appendix 4. Grading scores of sweet potato slices from farmers' stores - November 1996

NORTHERN ZONE - Kahama district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Mwabomba 1	19	1					2
2	20						5
3	8	2	10				4
4	17	3					5
Mean for each rank	16.0	1.5	2.5	0.0	0.0	0.0	
Mean loss =	0.3						
Nyambubi 1	16	4					4
2	20						2
3	10	8	2				6
Mean for each rank	15.3	4.0	0.7	0.0	0.0	0.0	
Mean loss =	0.3						
Ihulike 1	20						4
2	14	6					4
3	20						4
Mean for each rank	18.0	2.0	0.0	0.0	0.0	0.0	
Mean loss =	0.1						

NORTHERN ZONE - Meatu district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Bukundi 1	19	1					4
2	20						5
3	19	0	1				5
4	15	5					4-5
5	18	2					5
6	19	1					2
7	16	4					2
8	18	2					<1
9	20						4
10	20						3-4
Mean for each rank	18.4	1.5	0.1	0.0	0.0	0.0	
Mean loss =	0.1						
Malwilo 1	19	1					5
2	15	4	1				5
3	19	1					5
4	13	7					5
5	10	5	5				>12
6	19	1					6
7	20						4
8	16	4					5
Mean for each rank	16.4	2.9	0.8	0.0	0.0	0.0	
Mean loss =	0.2						

Sakasaka 1	14	6	-				5
2	19	1					4
3	14	5	1				4
4	18	2					4
5	20						>12
6	20						6-7
Mean for each rank	17.5	2.3	0.2	0.0	0.0	0.0	
Mean loss =	0.2						

Lubiga 1	18	2					6
2	11	3	6				7
3	16	2	2				6
4	17	2	1				4
5	15	5					4
6	18	2					5
7	15	4	1				5
Mean for each rank	15.7	2.9	1.4	0.0	0.0	0.0	
Mean loss =	0.3						

NORTHERN ZONE - Kwimba district

Village / Farmer	Rank						Months of storage
	1	1A	2	3	4	5	
Kishili 1	10	7	3				5
2	17	2	1				5
Mean for each rank	13.5	4.5	2.0	0.0	0.0	0.0	
Mean loss =	0.4						

Walla 1	19	1				-	4
2	8	6	6				6
3	19	0	1				5
4	5	2	9	1			4
5	4	4	9	3			4
6	12	7	1				4
Mean for each rank	11.2	3.3	4.3	0.7	0.0	0.0	
Mean loss =	0.6						

Kilyaboya 1	4	5	11				2
2	17	3					4
3	3	7	8	2			4
4	9	8	3				6
Mean for each rank	8.3	5.8	5.5	0.5	0.0	0.0	
Mean loss =	0.8						