INSECT INFESTATIONS AND LOSSES OF MAIZE, *ZEA MAYS* (L.) IN INDIGENOUS STORAGE STRUCTURES IN MOROGORO REGION, TANZANIA

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ABSTRACT

Insect infestations and losses of maize stored in four types of indigenous storage structures in Morogoro Region, Tanzania were investigated. Infestation levels and weight losses caused by the larger grain borer, Prostephanus truncatus *(Horn) and the maize weevil,* Sitophilus zeamais *(Motsch.) were found to differ significantly in the four types of storage structures (*Dari, Kihenge, Kichanja *and* Reli*). Lower infestation levels by the two pests and less weight losses were observed in* Dari *and* Kihenge *than in* Kichanja *and* Reli. *The infestations and weight losses exhibited a significant trend that was in the order,* Dari< Kihenge < Kichanja < Reli. *These findings suggest that* Dari *and* Kihenge *are more appropriate for the incorporation in Integrated Pest Management (IPM) for* P. truncatus *and* S. zeamais *in Morogoro Region.*

INTRODUCTION

Stored insect pest infestations are a major threat to maize, *Zea mays* (L.) stored in indigenous structures in rural Tanzania. Maize is a staple food and cash crop, grown and stored in almost all the rural areas in Tanzania (Acland 1975, Lupatu 1980). Storage of food crops is necessary to ensure regular supplies to households. At household level, maize is stored under traditional management conditions where it is susceptible to insect pest infestations. In most cases, insect pests constitute one of the principal causes of crop losses, both in the field and in storage, especially in the latter case where the crop is kept for a long time for later use. Post-harvest losses may account for up to 40% of the amount produced (Maunya 2002).

Since the 1980's maize storage has become severely threatened by the greater damage caused by the exotic insect pest, Prostephanus truncatus (Horn). The damage caused by this pest is reported to have rendered some indigenous storage systems inadequate (Dunstan and Magazini 1981, Makundi 1987, Anon 1995; Rugumamu et al. 1997). Initially the beetle got established in Tabora region, Tanzania and later the pest spread widely and is now reported in almost all regions of Tanzania (Golob et al. 1999). *Sitophilus zeamais* (Motsch.) is a cosmopolitan insect pest of maize in warm areas (Throne 1994). An assessment of damage caused to maize by these pests in different storage structures in rural Tanzania could provide results that would shed light towards designing an appropriate strategy for controlling the insects at the farm level, particularly in Integrated Pest Management (IPM).

Control of insect pests in rural areas is achieved by application of chemical pesticides in addition to traditional technologies. However, chemical pesticides can only be afforded by a few well to do farmers (Akhabuhaya 1980, Akhabuhaya and Lodenius 1988, Golob 1988). The use of chemicals against insect pests not only increases the production costs but also pose hazards to the smallholder farmers and the ecosystem in general (Carson 1962, Bottrel 1970, Nwana & Akibo-Betts 1982, Mushi 1984, Mushi *et al*. 1986). It is advanced therefore that the use of some indigenous technologies in rural areas might be a better management approach to insect pest infestations and would ultimately promote biodiversity conservation in storage ecosystems.

In rural Tanzania, indigenous storage structures are extremely important because approximately 80% of the harvest is stored in these facilities. A range of storage structures has been adapted as far as possible depending on several factors including the prevailing local climatic conditions. The size and method of construction of the structures correspond to the type and quantities of cereal to be stored (Lindblad & Druben 1980a,1980b, Bengtsson 1987). Local craftsmen and women normally construct indigenous storage structures. The structures are of low construction costs and comply with the availability of construction materials (Harnisch 1980, Rugumamu et al. 1997). The present study investigated insect pest species infesting maize and losses in four types of indigenous storage structures in Morogoro region.

METHODS

Study areas

The study was conducted for two storage seasons in Furwe and Mlali villages, Morogoro region, Tanzania (Fig. 1). Furwe village is located 50 kilometres east of Morogoro municipality on the Dar es Salaam - Dodoma highway. Mlali village is near Mlali township located 27 kilometres south of Morogoro municipality along the Mzumbe road. Furwe and Mlali are approximately 350 and 700 metres above Mean Sea Level (MSL) respectively.

Furwe lies on the plains about 150 kilometres west of the Indian Ocean at the foot of the Uluguru Mountains, Mlali is on the gentle slopes on the leeward side. There are 110 raindays producing about 1500 mm of rainfall with a peak in March and April. The temperature ranges from 150C to 28^{o}C with a mean of 25^{o}C, the highest temperatures are in November to February and the lowest are in June to September. The relative humidity is between 70% and 90% (Data collected from Sokoine University of Agriculture weather station).

Maize variety used in the trials

The maize variety Staha is the most favoured and commonly grown and stored in the study areas and was selected for the trials. This variety has both flint and dent grains. It is a high yielding composite variety that matures in about three months. To assure varietal purity, the maize samples for field trials were purchased directly from Tanzania Seed Company (TANSEED), Morogoro branch.

Indigenous storage structures

Miniature structures of the four indigenous storage structure types constructed by village craftsmen were *Kihenge*, *Kichanja*, *Reli* and *Dari*. *Kihenge* is a 1.5 m raised hut with poles that are fitted with rodent guards. It is grass thatched, plastered with mud and has a door on one side. Bags of maize are stored inside. *Kihenge* is usually constructed outdoors within the residential compound. *Kichanja* is a table-like platform usually erected inside a residential house. It is made out of pieces of wood (about 7 cm diameter) that are tied together by ropes and is raised to about a metre from the ground. *Reli* is made of racks of big pieces of wood (about 15 cm diameter) laid on the floor inside a residential house. *Dari* is made of racks of pieces of wood (about 7 cm diameter) laid on top of fireplace inside a house.

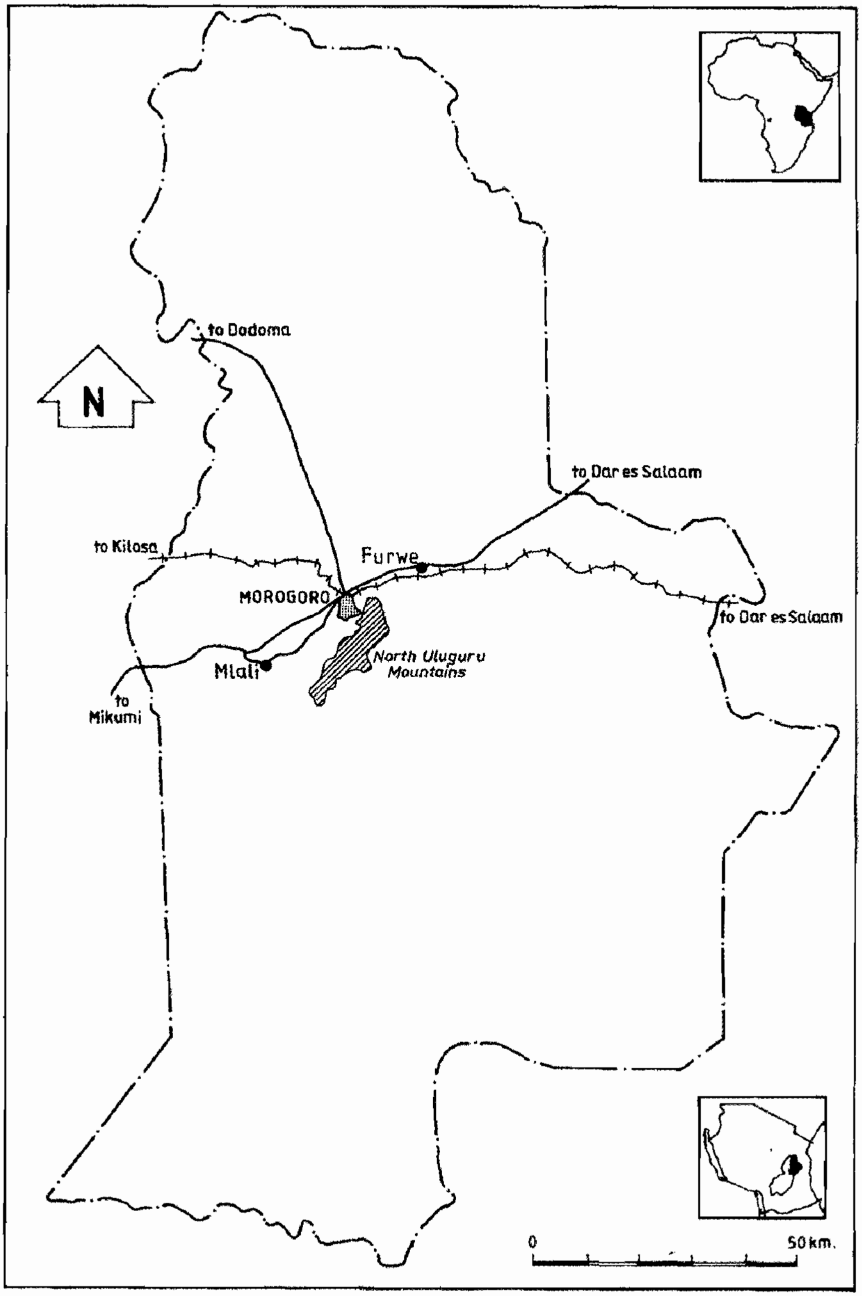

Figure 1: Location of Mlali and Furwe on Morogoro District

Storage trials

The four different storage structures were erected in selected sites with assured security. Storage of maize samples was done for two storage seasons. Freezing for three weeks first disinfested the shelled maize grains used in the trials. The maize samples were then sealed in big jars for conditioning to ambient conditions and protected from subsequent infestations for two weeks before being introduced to the experimental storage structures. Four maize samples each weighing 4 kilograms in six replicates were packed in miniature bags and stored in respective storage structures. Moisture content of the maize ranged between 11 and 12.5%. Storage lasted for six months; there were two sampling occasions at intervals of three months carried out in each storage season.

Insect infestation and damage levels

At each sampling occasion, the bags were removed from the structures and placed in plastic bags to prevent the insects from escaping. They were then placed in cooling boxes to immobilize the insects temporarily for ease of identification and counting in the laboratory. Insect infestation levels were established by counting the number of insects in each species and for each type of storage structure. Weight loss was established by comparing the initial with the final weight of the samples (Mphuru 1983). The actual weight losses were obtained after applying a correction factor due to moisture content changes from the controls.

Data analysis

Differences in the numbers of insect pests among the different structures were statistically tested with the Kruskal Wallis test. Means separation was carried out using Duncan Multiple Range Test. The same procedure was used for weight loss variations (Siegel 1956, Sokal and Rohlf 1981a, 1981b, Gomez & Gomez 1984).

RESULTS

Insect infestations

Four insect species, *Sitophilus zeamais*, *Prostephanus truncatus*, *Tribolium spp.* and Sitotroga *cerealella* (Olivier) were found infesting stored maize. S. zeamais were the most abundant, followed by P. truncatus, while *Tribolium spp* occurred in small numbers in both villages. *S. cerealella* was recorded in only two samples during the second storage season in Furwe village.

There was significant variation in insect infestation among the four types of storage structures for both *S. zeamais* and *P. truncatus* (Figs. 2 and 3; $P < 0.05$). In Furwe village, the H values were 18.61 and 21.00, for *S. zeamais* and *P. truncatus* respectively ($P < 0.005$). In Mlali the values for H were 21.49 for *S. zeamais* and 18.99 for *P. truncatus* ($P = 0.0002$). Insect infestations were higher in Furwe than those found in Mlali village. Multiple comparisons test indicated significant differences between all the four storage structures in both villages ($P = 0.05$).

Table 1: Mean weight losses (%) of stored maize in Furwe and Mlali villages (Morogoro, Tanzania) during the second sampling occasion of the two storage seasons 2000/2001 (mean of six replicates)

Storage Structure	Mean Weight Loss (%)	
	Furwe	Mlali
Reli	7.96 ± 0.04	7.00 ± 0.04
Kichanja	7.10 ± 0.07	6.65 ± 0.05
Kihenge	4.84 ± 0.03	4.14 ± 0.07
Dari	4.07 ± 0.08	3.57 ± 0.37

Damage levels

The weight losses of the stored maize during the second sampling occasion in Furwe village ranged from 4.07 ± 0.08% to 7.96 ± 0.04% (Table 1). In Mlali village it varied from 3.57 ± 0.37% to 7.00 ± 0.04% in the second sampling occasion (Table 1). In both villages the trend of weight loss of maize for the four storage structures was in the order, *Reli> Kichanja> Kihenge > Dari*. Weight losses among the storage structures in both villages varied significantly (H = 21.6 in Furwe and 20.94 in Mlali at P < 0.05, 3). . Multiple comparisons indicated that weight loss is significantly different between all four structures in the two villages (P = 0.05).

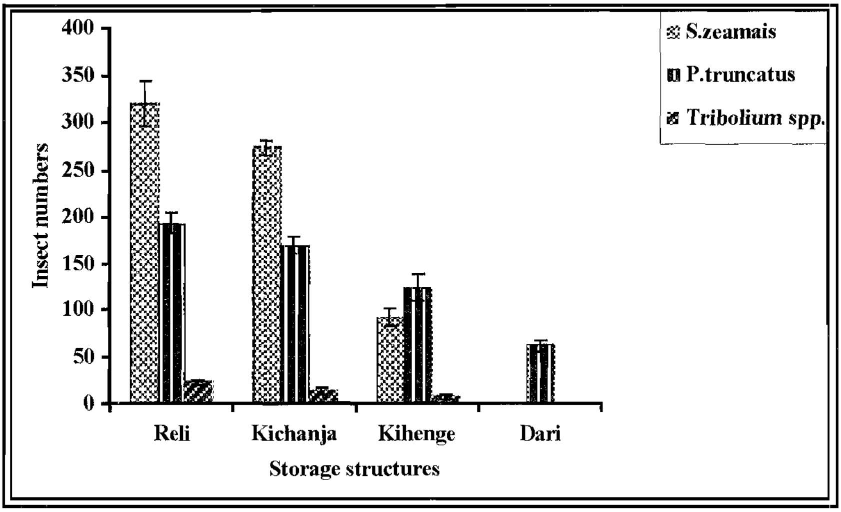

Figure 2: Mean number of insect pests from the four storage structures at Furwe sites (Morogoro, Tanzania) in the second campling occasion

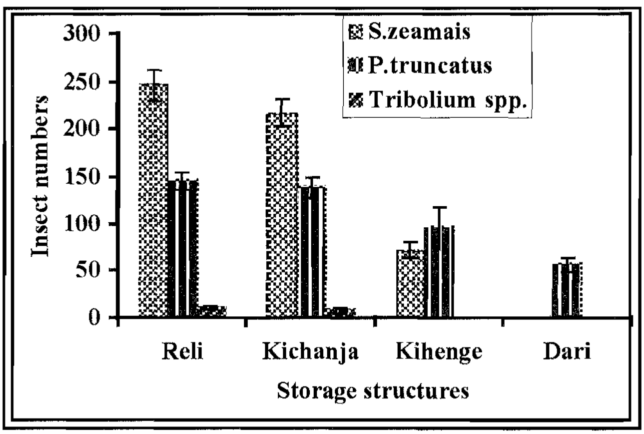

Figure 3: Mean number of insect pests from the four storage structures at Mlali sites (Morogoro, Tanzania) in the second campling occasion

DISCUSSION

Maize stored in the four indigenous storage structures showed variations in insect pest infestations and weight losses which were influenced by the type of storage structure. This observation is similar to those reported by Zehrer (1980), Pantenius (1988) and Goldman (1991) for traditional storage structures in Togo, Nigeria and Kenya.

The damage was mostly caused by the primary pests, *P. truncatus* and *S. zeamais*. However, in both villages higher numbers of *S. zeamais* than those of *P. truncatus* were found in all the storage structures. The intrinsic rate of increase of *S. zeamais* have been reported to be greater than that of *P. truncatus* (Shires 1980). In both villages the numbers of *S. zeamais* and *P. truncatus*, were higher than those of *Tribolium spp*., a secondary pest feeding on broken kernels and flour arising from feeding of the primary insect pests. The relatively low numbers of *Tribolium spp*. occurring in the four types of storage structures confirm its lower economic status than the two major primary pests.

The weight loss in maize corresponded with the numbers of *P. truncatus* and *S. zeamais* in each storage structure. This could be explained by the feeding behaviour of the two primary insect pests, particularly *P. truncatus* which converts maize grains into flour and frass very rapidly causing greater losses (Hodges 1986, Rugumamu 1992). Hodges (1986) reported weight losses of up to 40% in maize cobs in Nicaragua after six months of storage. Golob (1988) noted that the weight loss caused by *S. zeamais* was comparatively low. In the absence of *P. truncatus* the weight loss caused by *S. zeamais* after six months of storage has been reported to be approximately 3.01% (Hodges 1986). Therefore it could be reasonably argued that the weight losses were mainly caused by *P. truncatus*.

The performance of the indigenous storage structures in terms of preventing stored maize losses could be attributed to insect pest numbers which developed in them. The highest weight loss occurred in the reli type of structure where insect pest number was highest whereas the lowest pest numbers and weight loss occurred in dari. The location of the dari over the cooking fire exposes the maize to smoke and heat which impairs normal insect development and multiplication. Zehrer (1980) reported that some farmers in Togo smoke their maize for several days when it is harvested and also smoke the structures using green wood that produce plenty of smoke before the crop is introduced for storage. Also, exposure of the maize to heat from the cooking fire ensures continuous drying. The low moisture content of maize stored in the dari is unfavourable to insect infestations as compared to the other storage structures. However, low moisture content did not completely discourage infestation by *P. truncatus* which can thrive on maize with moisture content of less than 10% (Hodges et al. 1983).

Kihenge type of structure performed relatively better than *Reli* and *Kichanja* hence it was the second best. The Kihenge which is smoothly plastered and *roof* thatched minimize fluctuations of internal relative humidity and maize grain moisture content and is more difficult to infest relative to the other types of structures. Both *Kichanja* and *reli* structures expose the stored maize to insect pests' attack but the kichanja type has the advantage of not receiving moisture directly from the floor hence keeping the maize grains relatively drier than those stored on reli in which the wood pieces are laid directly on the floor. Burtt-Davy (1914), Gough and King (1980), Pixton (1982) and Wilbur and Mills (1978) noted that stored maize grains should have a moisture content ranging from 10 to 13.1% in order to avoid attack by most insect pests. The insect pest infestations recorded in Furwe village were much more severe probably due to the lower altitude than Mlali. The temperature and humidity in

Furwe were more favourable for the insect pests.

The indigenous storage structures studied did not completely prevent infestation by *P. truncatus* and *S. zeamais*. However, the variations in infestation levels observed suggest that some could be incorporated in IPM programmes at farm level. This could contribute to the reduced use of expensive and environmentally hazardous chemical pesticides in storage ecosystems. It is recommended that farmer-based participatory investigations be initiated in other regions in Tanzania in order to contribute more knowledge in indigenous storage structures and practices.

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