ASSESSMENT OF POST-HARVEST TECHNOLOGIES AND GENDER RELATIONS IN MAIZE LOSS REDUCTION IN PANGAWE VILLAGE EASTERN TANZANIA

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ABSTRACT

In this paper the use of gender sensitive technologies in the reduction of post-harvest maize losses at farm level is advocated as a strategy for household food security. The study was conducted in Pangawe village, eastern Tanzania. It employed participatory approaches to investigate farmers' perceptions on loss management. Storage trials were carried out to determine maize losses caused by insect pests in the sub-villages. Perceptions were analysed qualitatively and quantitatively. ANOVA assessed losses in storage trials. Major post-harvest processes included farm field; en-route; homestead and storage. All activities except winnowing were carried out by both men and women at varying participation levels using unimproved technologies. Losses at each process varied yet farmers perceived the greatest loss during storage. Storage trials exhibited different insect incidences. Losses in trials were significantly different among the four sub-villages (P<0.05) being lowest at Pangawe-Juu and highest at Legeza Mwendo. It is concluded that, the missing link in post–harvest maize loss reduction in all the phases in Pangawe is the availability of appropriate technologies. The Pangawe Community Post-harvest Action Plan (PCPAP) strategies are recommended as a model for rural areas for promotion of gendered maize post–harvest management in order to revitalize the agricultural sector.

INTRODUCTION

Research efforts the world over, and indeed in Tanzania have been expended in the search for increased yields of major food crops. However, it is of little use when crop production is increased by a big percentage if post-harvest loss risks are not directly addressed. These risks are mostly experienced by smallholder male and female farmers in developing countries who employ relatively inappropriate crop handling, processing and storage technologies.

Maize, *Zea mays* (L.), a cereal crop native to tropical zones of America, is one of the most widely cultivated gramineous plants in East Africa (Acland 1977). It is a staple food crop grown almost in all villages in Tanzania and hence its post-harvest management systems are of great concern to farmers and policy-makers (FAO 1995, Rugumamu *et al*. 1997). At national level, the National Strategy for Growth and Reduction of Poverty (NSGRP 2005) and the current "Kilimo Kwanza" (2009) underscore the need to address post-harvest loss reduction. In essence, this study is in line with FAO (1996) and the Millennium Development Goals (UN 2000) on the initiatives for promotion of food security and poverty reduction.

Post-harvest period is between physiological maturity of a crop and the time for its final consumption (GASGA 1978, FAO 1996, Nelleman et al 2009). In this regard, a rural post-harvest management system of a crop is typified by a set of systematic handling activities in a complex sequence of interconnected field and homestead operations undertaken by smallholder farmers. Each operation is unique in itself with regard to crop type; gender relations; the type of technology and attendant loss. It is worthy noting that while post-harvest activities in rural areas are labour demanding, manual labour is the most important factor for increased production (FAO 1988, 1995.).

Crop loss is referred to as any change that reduces its value to humans either quantitatively or qualitatively (FAO 1984, GASGA 1978, and Savary *et al*. 2006). The former includes loss of dry matter indicated by reduction in weight or volume while the latter covers loss of important qualities like germinating ability and nutritional contents. Crop losses may be caused by pest infestations, infections by pathogens and poor or inappropriate handling technologies (FAO 1996).

In the agricultural crop management, gender relations refer to a socially constructed involvement of men and women which are fundamental to the organization of farm work and to farm decision-making (Riley 2009). As reported by Meena (1992), Rugumamu *et al*. (1997), FAO (2003), Kingamkono (2006) for example, women are mostly responsible for ensuring household food sovereignty and security albeit their inadequate traditional technologies. Technology as a broad concept deals with human usage and knowledge of tools and crafts and how it affects human capacity to control and adapt to the environment (Wikipedia). FAO (2003, 2004), Creighton and Omari (2000) argued that in smallholder crop production, women are especially more likely to be socially and economically involved in post-harvest activities than men. There is, however, scanty knowledge on gender mainstreaming in the division of labour and gender sensitive technologies for post-harvest operations.

The objective of the study was to investigate and analyse the linkages between gender relations and post-harvest management technologies of maize at various phases in Pangawe village in order to develop loss reduction strategies. It sought to engender the processes and identify technologies as well as attendant losses. The knowledge gained could be used to promote research in gender and post-harvest management technologies aiming at minimizing crop losses between harvesting and actual consumption.

MATERIALS AND METHODS

Study Area

The study was conducted in Pangawe village constituted by four sub-villages namely, Pangawe-Juu, Pangawe-Kati, Majengo and Legeza-Mwendo in Morogoro district, eastern Tanzania. It was selected because of its relatively high potential for maize production and hence existence of various post-harvest management technologies (Morogoro Region Office). The village landscape varies altitudinal within short distances with Pangawe-Juu sub-village being higher than the rest.

Investigation of Community Perceptions on Maize Post-harvest Management

The study employed stakeholder participatory approaches according to PRA (1991) and Chambers (1994). Being community based, it was enriched by contributions from village meetings, focus group discussions (FGD), interviews and field observations. Information on technologies, gender roles and maize losses were thus investigated at each post-harvest phase on ten percent sample (62) (Babbier 1983) of able bodied farmers from the sub-villages using the above tools. The sample population was selected on a gender based stratified community using the village records (Village file notes). A two day stakeholders' workshop was conducted at the end of the study period to design a Pangawe Community Post-harvest Action Plan (PCPAP).

Determination of Maize Losses in Storage Trials in the Sub-villages

Storage structures

This experiment was carried out in the sub-villages using the popular and locally constructed storage structure known as "kichanja". The construction materials included *Azadirachta indica* poles which are relatively resistant to insect pests' attack. Three storage structures were erected for maize loss trials in each sub-village.

Stored maize samples

Maize grains for the storage trials were disinfested by freezing for three weeks and then equilibrated to environmental conditions for seven days. Six replicates of disinfested samples of 5 kg each were packed in miniature gunny bags and placed in each of the three structures in each sub-village for a three month storage period. Thereafter, the samples were removed from the structures for insect pest species identification and counting. Sample weight losses were determined by a Sample Weight Method according to Dobie (1974).

Data Analysis

Responses of stakeholders on the relationship between post-harvest management technologies and gender relations were analysed qualitatively by SPSS. Weight losses of maize in the storage trials were analysed using one way ANOVA. Relative abundances of insects from stored samples in the sub-villages were calculated (Gomez and Gomez 1984, Zar 1996).

RESULTS AND DISCUSSION

Social Status, Maize Production and Post-harvest Processes

The marital status of most interviewees was found to be 80% married while12% and 8% were single women and men, respectively. For education, 25% of the members had not gone to school and 28.8% females and 30.8% males had primary education while 15.4% males had secondary education. No single female had attained secondary education. A negative cultural attitude towards women's education reflected by early girls' pregnancies and/or marriages contributed significantly to girl child drop-outs from school.

Field data revealed that maize production was relatively low as most households (92%) produced between 500 and 1000 kg annually. Farm plots were between one and two hectares. The low production was attributed to unimproved technology applied in farms. Farmers reported that because of the productivity, preferred to grow the different maize varieties in the following order, Staha (85%), Locals (80%), Katumani (76%), TMV_1 (62%) and Kito (54%). Open pollinated varieties were preferred to hybrids because they offer the potential for continuing evolution at local level (Lupatu 1980). All varieties were used for making "ugali" a traditional stiff porridge and "kande" a dish of mixed maize and beans. Local brews, "Komoni" and "Kangara" are made from maize grains and grain husks, respectively.

The post-harvest processes of maize in the Pangawe case study were classified into four major phases. The first phase is farm field-based which include de-sheathing and piling harvested maize cobs which takes place at physiological maturity; the second is en-route-based when cobs are transported from farms to homesteads; the third is homestead-based phase which constitutes drying and grading of cobs, shelling of cobs and drying the grains, winnowing of grains, application of pesticides, packing grains at household level and the fourth phase is storage-based where grains are stored for later use (Table 1).

Analysis of Technologies, Gender Relations and Maize Losses

Farm field-based post-harvest processes

In de-sheathing maize cobs, knives of various sizes and sharpened wooden tools were used by 25% women and 11% men while 100% women and 98% men reported use of bare hands. Cobs were packed in baskets and/or in gunny/polythene bags. 71% respondents reported that men, women and children played the role of ensuring that all harvested cobs are transported while 29% indicated that only women carried out these processes (Table 1). Further, some women had formed an association to enhance rapidity and efficiency in this crucial activity aiming at minimizing losses.

Table 1: Responses of farmers on the participation (mean %) of men and women in post- harvest activities in Pangawe village

Activity	Participation % of gender categories		
	Women	Men	Both
De-sheathing, piling and Packaging	29	0	71
Transportation	08	48	44
Drying cobs	40	10	50
Shelling	65	10	25
Drying grains	90	0	10
Winnowing	98	0	2
Pesticide application	70	0	30
Packaging	36	14	50
Storage	30	0	70

Losses were caused by insect pest infestations; damage by rodents; theft; negligence in cob collection; loss of grains from over-dried cobs; germination of grains due to untimely on-set of rains; cobs obscured by weed. The estimated losses in different production levels ranged from less than 5 to about 45 kg. Such losses were considered by farmers to be negligible though some were actually higher than the acceptable loss of less than 3% (Hodges 1982).

En-route based processes and crop losses
Invariably it was found out that cobs were transported from farm fields to homesteads along tracks. 75% women used head transportation and 84% of men employed wheel burrows and hired bicycles. Bicycles, wheel burrows and tractors were reported to be least used by women given their vulnerability. Females who were head of households transported their produce in small quantities within a relatively long period compared to single males. As argued by Anon. (1977) family size could be related to losses incurred. Given the popularity of head transport and that the operation called for rapidity, it involved all able bodied household members.

Maize loss at this stage resulted from the pre-harvest insect infestations, theft and damage from dump weather conditions but was conceived to be minimal by farmers. Such losses were avoided by some few farmers who could hire tractors for the crop transportation. It was reported that in some instances district authority directed business persons to expedite transportation of the produce. In this regard the nature of transport could be related to the amount of crop loss (FAO 1995). Critically, farmers expressed a need to acquire a quick means of transport to salvage the crop.

Homestead-based processes and crop losses
Maize cobs were spread on mats, polythene/canvas sheets and/or on “Vichanja” to be dried by solar radiation and on “Dungu” (drying structure hanged over cooking fire) to be fire cured. The process reduced grain moisture content to acceptable levels before storage. was carried Both men and women carried out the activity though at

varying levels (Table 1).

Losses were caused by free-range chicken and other wild birds feeding on the grains. Rodents caused loss in "Dungu" and insect pests mainly the Maize Weevil, *Sitophilus* spp. and the Larger Grain Borer, *Prostephanus truncatus*. These serious primary insect pests of maize start infesting maize on cobs while in farms (Rugumamu *et al*. 1997). Small amount of crop loss was encountered at this stage as revealed by 95% farmers. Grading of maize on cobs was undertaken by experienced women who apply their ingenuity to calibrate a 'physical quality assessment scale'. Women were reported to have a leading role in determining maize genetic material to be preserved and reproduced. This undocumented skill is passed from generation to another through the maternal line.

Shelling of grains involves detaching grains from well dried cobs and is done by hand and by use of simple tools. Locally made wooden pestle and stick were used by 60% of farmers while others could rub two cobs against each other. Another technique was to use a wooden stick to carefully strike gunny bags containing cobs. Wooden shelling platforms were locally designed by craftsmen to enhance shelling. Four stout pieces of wood are erected from the ground in the form of a rectangle. Then four poles are fitted across to form a bed-like structure and a wire mesh spread and fixed on the corners. Then cobs are spread on the mesh and pounded with a stick. A polythene sheet spread beneath the structure was used to collect the grains. This improved technology when available was used by both men (75%) and women (22%). The technique was preferred for its capacity to expedite shelling and to minimize grain damage.

It was found out that grains were preferred to cobs for storage as they thoroughly mix with pesticides. Shelling is also one of the coping strategies against *P. truncatus* since grains are less susceptible to attack than maize on the cob (Golob et al. 1999). In order for grains to attain 12.5% to14.0% moisture content recommended for maize storage (Lindblad and Druben 1980, FAO 1984) they were spread on mats and/or on polythene sheets and exposed to solar radiation for about three consecutive days to dry up. Dryness of grains was assessed and determined by mostly women who crashed them with teeth. Losses were considered negligible.

The winnowing process separates and removes waste materials from grains. Women were reported to possess the art and science of holding and shaking reed-woven trays of different sizes while capitalizing on wind speed and direction for efficiency of this technology. When hired, a woman could winnow 600 kg a day. Minimal losses were reported to be caused by an individual's carelessness. Although maize was infested by insects at this stage, some respondents were unaware of the subsequent future losses. Dobie *et al*. (1984) reports that, maize infestations start in farm fields and follow a typical pattern in rural storage where the build-up tends to be slow in the first month after harvest and expand exponentially thereafter.

Storage-based processes and crop losses

This was conceived as a sensitive phase to farmers since poor drying of grains and subsequent storage techniques could lead to high insect infestations as well as fungal infections. Fungi introduces mycotoxins such as aflatoxin whose health impacts range from acute poisoning, and in some cases death, to long term carcinogenesis development (FAO 1995). Crop losses were reported to be comparatively higher than in other phases. Some farmers practiced Integrated Pest Management (IPM) by simultaneously applying the industrial and traditional pesticides as well as keeping cats, a natural predator of rodents. Actellic Super dust, a compound of Organophosphorous and Pyrethroid (Pirimiphos methyl +

Permethrin) which kills both *Sitophilus* spp and *P. truncatus* (TZ-GTZ 1996) is well known and recommended to farmers but rare in the study area event when in stock it is unaffordable. Based on farmers' perception, minimizing stored crop losses could be achieved by employing relevant management technologies in an integrated approach.

Indigenous pesticides used by most farmers include, ashes from rice husks and maize cobs; cow and goat dung; cooking oil; powder of *Azardiachta indica* leaves. Women were involved in applying materials to grains and packed them in new and/or cleaned bags that were sealed by stitching. The packed maize was systematically piled on rudimentary storage structures in most households. In rare instances (8%) metallic and or plastic drums were used for storage. Men and women participated at various levels in the storage-based processes and the bottom-line was to take strategic interventions to limit losses which have no compensatory option (Okiwelu *et al.* 1987). Technologies employed and gender relations in the four different sub-villages were reported to be the same in all the post-harvest processes. However, comparative analysis from questionnaires indicated varying maize losses during storage in different the sub-villages as follows, Legeza Mwendo> Pangawe-Kati > Majengo > Pangawe-Juu. It was observed that whereas some processes were conducted by women and others by both women and men, there was no any one process which was carried out by men alone.

Table 2: Mean weight losses (%) of maize and relative abundance of insect pest species from four trial sites (sub-villages) after a three month storage period

Trial site (sub-village)	Mean weight loss (%)	Insect species	Insect relative abundance in %
Majengo	14.00 ± 0.16	*Ephestia cautella* (Hubner)	2.02
		P.truncatus (Horn)	25.50
		S. zeamais (Motsch.)	62.48
		Sitotroga cerealella (Olivier)	6.00
		Tribolium castaneum (Herb.)	10.00
Legeza Mwendo	*16.47 ± 0.21*	*P.truncatus (Horn)*	28.00
		S. zeamais (Motsch.)	68.00
		S.cerealella (Olivier)	3.00
		T.castaneum (Herb.)	7.00
Pangawe-Kati	16.21 ± 0.08	*E. cautella* (Hubne)	1.00
		P. truncatus (Horn)	26.52
		S. zeamais (Motsch.)	70.00
		S. cerealella (Olivier)	4.08
		T. castaneum (Herb.)	4.40
Pangawe-Juu	12.52 ± 0.09	*E. cautella* (Hubner)	1.02
		Oryzaephilus surinamensis (L)	11.00
		P. truncatus (Horn)	20.00
		S. zeamais (Motsch.)	65.98
		S.cerealella (Olivier)	5.00
		T.castaneum (Herbst)	7.00

Farm Storage Trials in the Sub-villages

A rapid three month farm storage trial in the sub-villages revealed occurrence of insect pest incidences resulting in significant differences in maize losses among the sub-villages at $P < 0.05$. It can be advanced from the findings that the concealed development of insect pest population build up in storage may have created a mystery to farmers regarding the cause of greater losses of maize in this phase. The comparatively lower temperature and humidity prevalent in Pangawe-Juu which is located at a higher altitude might have negatively influenced development of insects while in Legeza Mwendo at a lower altitude where the conditions are relatively higher might have favoured insect development (Dobie *et al.* 1984, Chapman 1998)

Further, the relative abundance of the primary insect pests, *P. truncatus* and *S. zeamais* were highest in Legeza Mwendo and hence causing greater losses (Table 2). It was also noted by GASGA (1978) that maize weight loss in rural storage is positively correlated with the number of infesting primary insect pests. Infested grains are thus undesirable on the market, causing both great economic loss to the producer and quality loss to the consumer (FAO 1984). It was therefore suggested in GASGA (1978) that storage at community level could provide more efficient grain management technology than at household level.

Extension Service

Technical assistance to farmers on post-harvest was reported to be provided by agricultural extension staff only once a year. Most participants were dissatisfied with the practice, a factor that increases human incapacity to cope with losses resulting in high crop loss risks (ZCC-eastern 2000, Walsum and Kolli 2001, Walsum 2002, Hopkins and McKeown 2002).

Many extension programmes have been based on the incorrect assumption of trickle across, that is, from men to women or vise versa (FAO 1995, Ross and Ross 2002 and 2003). It was revealed in this study that activities performed by both men and women in various phases were perfect and done on time. It can be argued therefore that losses could be reduced when both gender categories get access to pertinent extension service. The findings are in line with Walhaj and Harti (2007) who reported that involvement of men and women in development activities is a key to successful gender mainstreaming. It was also found out that lack of specialized training in the post-harvest component of the crop management cycle and lack of a lead farmer/practitioner as a coordinator hinder rapid and efficient transfer of appropriate technologies.

Pangawe Community Post-harvest Action Plan

Men and women in Pangawe village voiced the need for simple/medium level, time and energy saving technologies for the post-harvest crop loss reduction. The formulated strategies for maize post-harvest management in the PCPAP were first, equitable division of labour between men and women in all process activities and second, intensification of extension services coupled with the increased motivation for innovation of improved gender sensitive technologies. In this regard, the findings are in line with Nerlove (1988), Song and Jiggins (2002) who advanced that willingness of farmers to take advantage of educational and extension services and the provision of certain types of infrastructure can be enhanced by changes in the nature of investments including on-farm physical capital.

CONCLUSIONS AND RECOMMENDATIONS

In Pangawe village post-harvest maize losses are a function of complex interactions between men and women farmers on one side and the technologies they employ, on the other. The involvement of both men and women in the sensitive operations indicates that some gender relations concerns were appropriately addressed. In this regard, it may be concluded that the only missing link in post–harvest maize loss reduction in all phases in Pangawe is the availability of appropriate technologies. The PCPAP strategies are therefore highly recommended as a model for other rural areas in order to promote sustainable gendered post–harvest management systems of maize for revitilising agriculture in Tanzania.

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