Journal of Biology, Agriculture and Healthcare www.iiste.org
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.10, 2014

Farmer's Knowledge on Selection and Conservation of Cassava (*Manihot esculenta*) Genetic Resources in Tanzania

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ABSTRACT
Farmers have traditionally depended on their knowledge to cultivate diverse set of crop population for their subsistence. This practice has contributed to high genetic diversity found in farmers' fields. Occurrence of natural disasters has threaten survival of crop populations and diversity, and thus causing food shortage. Breeding efforts have been targeted to develop crop varieties which can tolerate these natural disasters but there has been poor adoption by farmers. There is a need to understand social and biological factors which farmer base on during selection and maintenance of their genetic resources. There is limited information for researcher's understanding of factors that farmers considered for landraces selection and conservation. In a view of the above mentioned problems a study was conducted using PRA tools to gather information on conservation of cassava genetic resources. The study found that farmer's decision on what landrace to plant was what has shaped the diversity. Farmer's decision comprised of diverse factors from food security, market forces and culinary attributes. The study found that seed (stem cuttings) flow occurs as farmers exchange or buy from local market. These exchanges occur within and outside the village. Most of cassava landraces were indigenous to the place and have been grown for more than 40 years, and only 8.4% were newly introduced. There was considerably loss of landraces due to disease, pest and drought outbreaks. Landrace selection decision was made by both men and women and these decisions on the other hand influenced the diversity of cassava landraces found in farmer's field. Cultivars like *Kiroba, Kibandameno* and *Msenene* were found in every farmer's field in those particular areas but other cassava landraces differed considerably from one field to another. It is concluded that farmer's knowledge is useful in conservation of cassava genetic resources for improved livelihood. Therefore farmer's knowledge should be incorporated in research intervention packages to be able to address specific needs of farmers in a particular area and fasten the adoption process.
Keyword: Farmer's knowledge; Genetic resources; *Kiroba*, Farmer's decision making.

1. Introduction

Cassava (*Manihot esculenta* Crantz) is a perennial woody shrub with an edible root that grows in tropical and subtropical countries. The starchy roots of cassava provide more than half of the calories consumed by over 800 million people in Sub-Saharan Africa (SSA), Latin America and Asia (Shore, 2002). Cassava is also the world's fourth most important staple crop after rice, wheat and maize. It plays an essential role for food security, especially in regions prone to drought and with poor soils. Cassava has ability to grow and produce on low nutrient soils, where cereals and other crops do not grow well and is suitable for incorporation in various cropping systems (Onwueme, 1978; Lekule, 2007). These attributes make cassava an important crop for smallholder farmers in the tropics where availability of agricultural inputs is limited.

Plant genetic resource conservation is continual cultivation and maintenance of diverse set of crop population. Farmers grow relatively large number of crops and varieties to reduce risks of food insecurity (Pujol *et al.,* 2007). Diversity of species in the environment has shown to contribute to the sustainability and productivity of the ecosystem (Berlon, 1997). Germplasm diversity, form a base from which farmers acclimatize to crop changing environment especially drought, disease and pest outbreaks. Therefore role of germplasm diversity to farmers' wellbeing cannot be ignored.

Farmer's knowledge can be defined as knowledge that is specific in cultural settings and which brings out interaction between crops and human communities (Mistry, 2009). Farmer's knowledge is adapted through local cultural and environment and forms a basis for farmer's decision making in management of genetic resources. The knowledge about cassava cultivars has progressed since its cultivation and farmers have traditionally depended upon their own skills and resources to develop cassava cultivars they needed (Tripp and van der Heide, 1996). Farmer's knowledge guides maintenance of crop genetic diversity but also potential utilization options. Farmer's knowledge is also important in cultivar identification and characterization. A study conducted in Malawi by Mkumbira *et al.* (2003) reported that farmers accurately distinguished between bitter and sweet cultivars. This is interpreted as farmers' knowledge on the potential risks of poisonous effect of cyanogen glucosides in the roots. Farmer's knowledge is also considered as an important component of conservation strategy. Farmers have diverse supply of germplasm to meet their household needs and their decision to delineate whether certain populations are maintained or abandoned has structured the genetic diversity of crops. It is therefore important to understand the process that lead to maintenance or loss of particular germplasm in farming system (Karamura *et al*., 2004).

Farmers ensure their subsistence and livelihood by selecting crop cultivars in accordance to their particular agro ecological conditions and culinary traditions. Researcher have mainly targeted high yielding and resistance to diseases and pest criteria. These criteria are targeted one at a time during variety development and studies have shown that there is poor adoption of these new varieties by farmers. Cassava is becoming important crop due to its drought tolerance and also the quality and quantity of its starch. It is important to understand how traditional farming operate so that research intervention for crop improvement can be operational. Therefore the objective of this study was to assess farmer's knowledge on cassava genetic resource management thus providing better understanding of farmer's cultivar preference, selection criteria, crop management practices, utilization options and post-harvest handling that influence maintenance of cultivars. In response to that, participatory rural appraisal tools and face to face interviews were used to gather information on underlying factors that influence farmer's decision to maintain or abandon cultivars.

2. Methodology

2.1 Study area

The study was conducted in the Eastern zone of Tanzania, which includes four regions namely; Coast, Dar es Saalam, Tanga and Morogoro. Major cassava growing districts were selected from each of the three regions excluding Dar es Salaam city. The climate of these regions is generally similar but there are differences in soil characteristics, temperature and rainfall distribution. The rainfall pattern received is bimodal, whereby two distinct rainy seasons are experienced in a year

2.2 Data collection

A purposive sampling procedure was employed to identify districts, villages, and farmers in the study areas. Three districts namely- Muheza, Mkuranga and Morogoro rural were selected for this study, due to their potential for cassava production. A total of 179 farmers from the three regions were involved in the study and the target group for this study involved experienced cassava farmers. Primary data were collected using participatory tools and interviews. Participatory methods used were focus group discussion, key informants and transect walk. Interviews and discussion with farmers were carried out using semi structured questionnaire. Focus group discussions were designed and conducted to validate response from individual farmer's interviews. Information on social economic activities, cassava cultivation, production constraints, seasonal activity calendar and cassava processing methods were collected. Listing and ranking of crops grown, cassava cultivars, constraints to production and selection criteria were done. Secondary data were obtained from village and district reports.

2.3 Data analysis

Coding of responses from the interview was done and then summarized into Excel Window program (2010). STATA 12 was used to analyze descriptive statistics and regression analysis. The descriptive statistics involved computation of statistical mean, frequency distribution and cross tabulation. The regression model (equation below) was derived to identify the relationship between cassava acreage and selected socio economic factors. The economic factor included; number of other crops grown by the farmer (X_1), cassava production for household food (X_2), gender (X_3), education (respondent years in school X_4) and cassava yield (X_5) (t/ha).

Analytical model

$$Y=\beta+\beta_1 X_{1\iota}\, j+\beta_2 X_{2\iota}\, j+\beta_3 X_{3\iota}\, j+\beta_4 X_{4\iota}\, j+\beta_5 X_{5\iota}\, j+\varepsilon_{\iota.}$$

3. Results and Discussion

3.1 Description of the farming system

The survey comprised of 69% men and 31% women of which 90% had formal education and 10% were illiterate. Farmer's age ranged from 32 to78 years. The largest group was that of 45 years and above (Fig 1). The study found that farmer's knowledge is passed on from one generation to another, and in each they adapt and add to it. It has been previously reported by Osawaru and Dania-Ogbe (2010) on study of enthobotany of okra that older and young ages have different knowledge and experience, thus putting together enhance the understanding

Journal of Biology, Agriculture and Healthcare
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regarding the crop management practices. Correlation between farmer's age and total land owned was significant at p value = 0.001. Also older farmers were found to cultivate large number of landraces compared to young one and they also own large cassava farms. A study done in Duupa, Cameroun (Alvaren *et al*., 2005) also found out that older farmers were the source of seeds, as they own large seed bank and farm land. This implies that as farmer become older their ability to acquire more land increases.

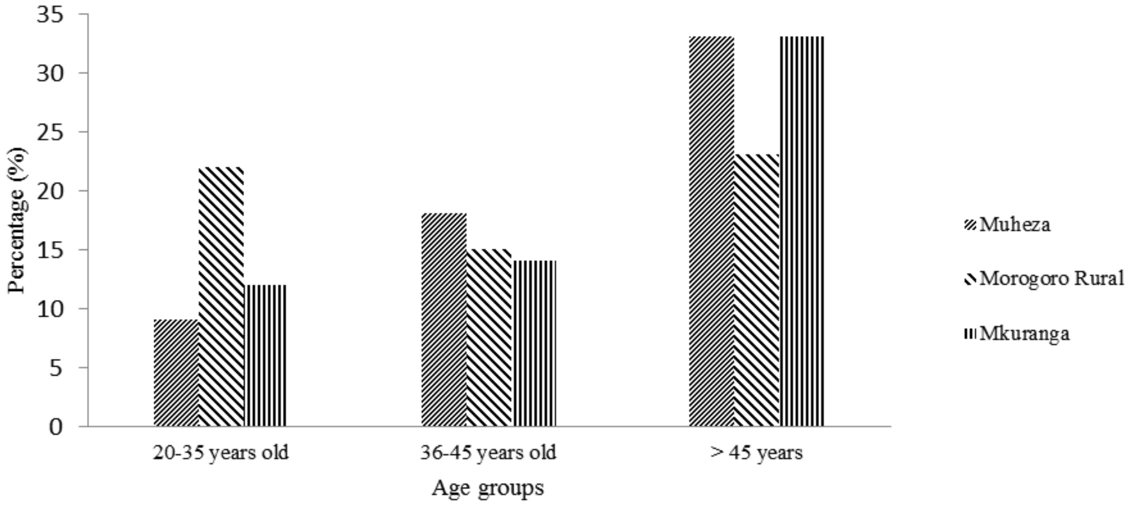

Fig 1: Age of respondents

Cassava was found to be grown as both food and cash crop. Also, maize, banana sweetpotato and cowpeas were common food crop grown in the area. Average household land allocated to cassava was 0.75 ha and ranged between 0.25 and 9.5 ha while average household land allocated for other crops was 0.84 ha. Farmers operated fragmented farm plots and on average a farmer owned 2 plots with average of 1.56 ha. Cassava was also grown in home gardens (plots) and mainly sweet landraces were found to dominate these plots.

3.2 Seed flow (stem cut) and landrace selection

The collection of landraces was found to be important for maintenance of diversity for livelihood of cassava farmers. The study found that cassava farmers continuously collected new landraces, performed on farm experimentation and finally incorporated new landraces in their farming systems (ref). The survey found that seed flow happened as farmers exchanged or marketed seed. These exchanges occurred among potential cassava farmers within the village and from one village to another. Farmers collected cassava landraces with superior attributes than what they had. Most of cassava landraces found in the area were indigenous (75.4%) and have been grown for the past 40 years, while few (8.4%) landraces have been introduced from outside regions and others were brought in by research institutes through extension services (16.2%).

Exchange of landraces within the village was common in the area and the newly introduced landraces were found to easily spread among the community. For example, *Kiroba* originated from Rufiji and was brought to Muheza and other parts of Eastern zone in 2005. *Kiroba* has become popular and was found in every farmer's field during the study, due to high yielding properties and resistance to common virus disease (Kanju *et al.,* 2002; Mkamilo and Jeremiah, 2005). Introduction of this variety has made farmers to abandon some of the landraces which were popular and were cultivated in high proportion. Farmer's decisions to maintain, discard or incorporate landraces in farming system was found to influence genetic resources maintained by farmers. Bellon (1997) reported that farmer's experimentation, evaluation and communication forms a basis for management of diversity for improved livelihood.

This study found that there was equal involvement of both gender in landrace selection and deciding proportion of each landrace to be grown. There was also equal involvement in the cassava production and management. Farmer's decision to select landraces to be planted in their fields have been found to affect introduction and exchange of cassava landraces. Based on the interviews, variety selection decision was found to be made by both men and women (76%), although in few households men were responsible for variety selection (12%) and women (11%) in female headed households. These decisions influenced the diversity of cassava landraces found in farmer's field.

Results summarized in Table 1 show different criteria which farmers use to select landraces to be grown and each had important role. These criteria formed a basis from which farmers decided type of landraces to be planted and proportion of each landrace in their farms. The results showed that the important criteria for landrace selection were high yield, early maturity and disease resistance. This study found that farmer's selection criteria and preferences formed a base for experimentation, evaluation and conservation. High yield was an important criterion which cassava farmers considered during variety selection followed by disease resistance and early maturity. Cassava diseases which were found common to the region included; Cassava Mosaic Disease (CMD) and Cassava Brown Streak Virus Disease (CBSVD). This observation is also supported by studies done by Mkamilo and Jeremiah (2005). The other factors which were pointed out were culinary attribute (taste and mealness), food security and market demand. Decline in yield and susceptibility to diseases has cause farmers to abandon landraces such as *Kitumbua, Hakungwa* and others. However, it has been found that farmers considered all of the mentioned criteria as important, and have influenced the decision making in landrace selection. There is no single landrace that address all farmers concerns and preferences, because landraces have both strong and weak traits.

Table 1: Farmer's landrace selection criteria

Criteria	Percent (%)
High yield	27
Early maturity	21.1
Marketing	17.8
Diseases and pest tolerant	12.7
Taste	11.1
Dry matter content	7.6
Drought resistance	2.7

The study found that, farmer grew some of the varieties for business only. Such varieties are not necessarily consumed at home and as a result, farmers grew a number of landraces and in different proportions to suit their preferences. At least 80.1% of farmers in the surveyed area grew an average of three landraces and a maximum of six landraces. Farmers gave reasons behind growing large number of landraces and are summarized in Table 2. Farmers had maintained many cultivars in their fields and they could easily differentiate them. They had developed morphological descriptors which they used to distinguish cassava cultivars (Figure 2). Stem color and leaf morphology were important features used by farmers to distinguish cassava landraces. Furthermore cultivars like *Kiroba* and *Kibandameno* (in Muheza and Mkuranga) and *Msenene* (in Morogoro) were found in every farmer's field but other landraces differed considerably from one field to another. Also farmers had maintained some of the landrace for over 40 years (generation) and these landraces included *Kibandameno, Mahiza, Msenene Kilusungu* and *Kiroba.*

Table 2: Reasons for growing different cassava landraces

	Responses	
Criteria	Number	Percent (%)
Food security	102	33.4
Taste/ Mealness	83	27.2
Market demand	81	26.6
Pest and disease management	24	7.9
Increase yield	15	4.9

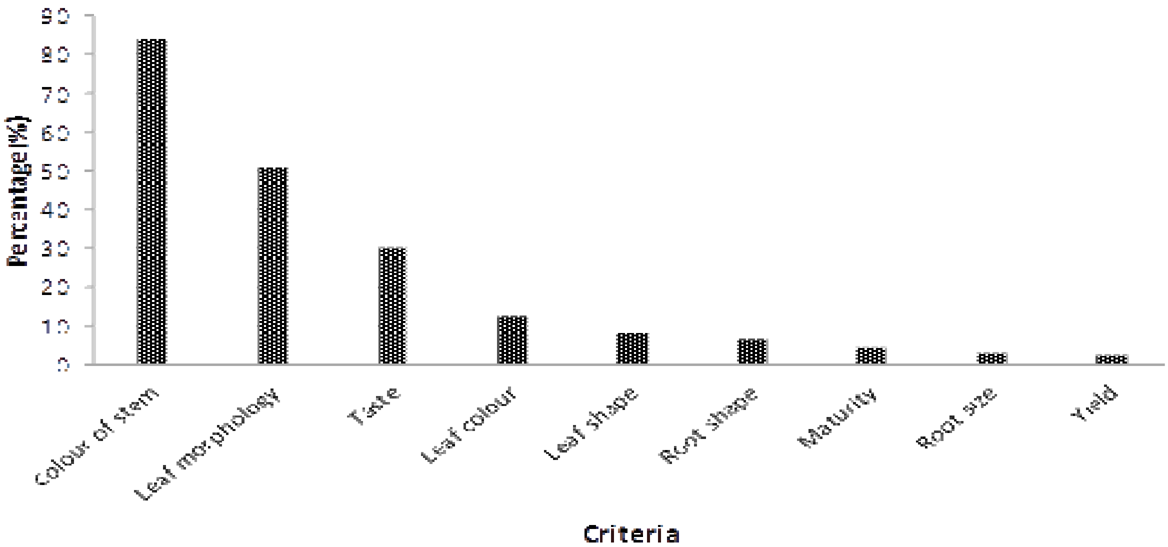

Figure 2. How farmers differentiate landraces

Farmers maintained different cassava landraces with an average of two cultivars per farmer as reported by Oluwole *et al.* (2007). There were varieties grown merely for food, market and as famine reserve. Food security was the main reason behind maintenance of different landraces, followed by taste and market. To ensure food security in case of adverse conditions farmer planted both short (6-9 months) and long (12-18 months) duration landraces. Clawson (1985) also reported that farmers used landraces with different maturation period to ensure sufficient food supply throughout the year. These cassava landraces were grown at the same time and in the same field but farmers could differentiate them. The study found that farmers had well adapted knowledge on how to distinguish cultivar and the most common criteria used were stem color and leaf morphology. Mkumbira *et al.* (2003) also reported that cassava farmers in Malawi, accurately distinguished cultivars using stem color, leaf shape and petiole color. This study also found that farmers have well adapted descriptors for cultivars identification. Farmers were able to identify sweet and bitter varieties and it reflected their knowledge on potential risks of poisonous effect of cyanogen glucosides. These bitter varieties were grown because of their long shelf life and also as protection against theft. Farmers were aware of the potential risks of cyanogen glycoside, and processing methods for removal of this toxic compound before consumption was well adapted. Varieties like *Sufi* and *Mahiza* were low yield but are preferred because of the sweet taste and soft texture and were thus grown for home consumption. It has been found that farmers grew a mixture of cassava landraces to supplement the positive and negative traits within the landraces. Therefore careful consideration is required by researchers during introduction of new varieties, before it can be accepted by farmers.

3.3 Production and management practices

Cassava planting season was found to vary. Where as in Tanga and Coastal region this was found to be March (long rain), in Morogoro it was October (short rains). High diversity of cassava landraces was found and the landraces which were popularly grown by at least each farmers were; *Kiroba* (51.7.3%), *Kibandameno* (15.7%), *Msenene* (19.2%), *Nyamkagile* (8.1%) and *Mwarusha* (5.2%). Intercropping dominated the three regions studied (Fig. 3). Cassava was found to be grown together with maize, cowpeas, coconut, banana, pigeon peas, and citrus fruits. These crops were found intercropped with cassava or grown in separate fields.

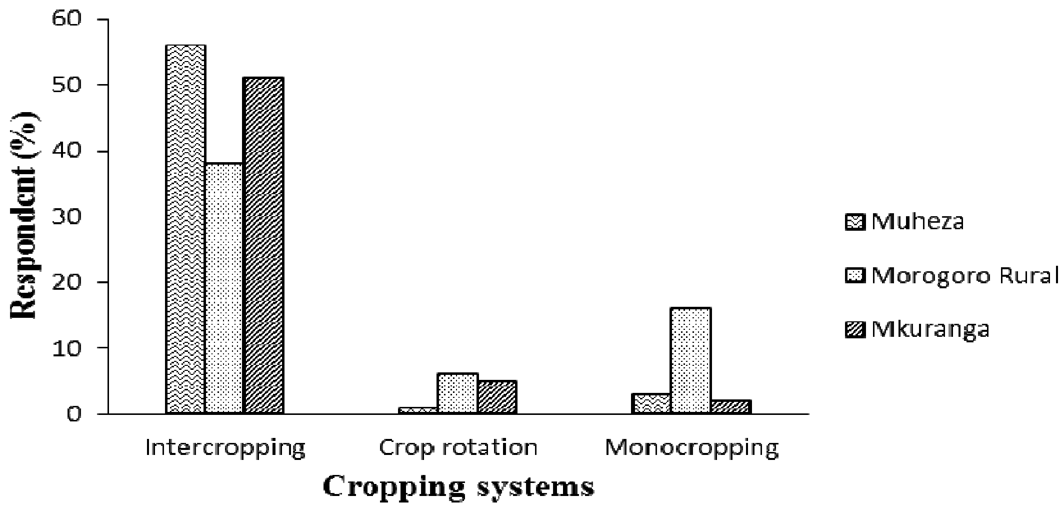

Fig 3: Cropping systems practiced in the study area

Farmers operated fragmented plots, including small plots at homestead (home plots) where they grew different landraces for home consumption. Newly introduced landraces were planted at these home plots to easen farmer's evaluation of their performance. Karamura *et al.* (2004) reported that growing mixture of cultivars near homestead had advantage of maintaining large gene pool and food security in case of disasters like drought or outbreak of diseases. Cassava was mainly planted in flat land and weeding was usually done three to four times. Fresh cassava root production ranged between 0.69 and 33 t/ha per household. Muheza had highest yield of between 1.5 and 31.25 t/ha followed by Morogoro (1.25 to 30 t/ha), and lowest yield was found in Mkuranga ranging from 0.69 to 13 t/ha and. Land allocated for cassava was found affected by several socio economic factors as illustrated in Table 3.

Table 3: Determinant of cassava acreage

Variable	Proxy parameter	Estimated coefficient	Standard error	t-value
constant	β	0.278*	0.283	0.98
Number of other crops grown (number)	β_1	0.061**	0.028	2.17
Food production (dummy,1=food production)	β_2	-0.049	0.107	0.48
Education (years in school)	β_3	0.014	0.011	1.17
Cassava yield (t/ha)	β_4	-0.024*	0.006	4.08
Gender(dummy,1=male)	β_5	0.103 ***	0.064	1.54
Age (number of year of HH)	β_6	0.005	0.004	1.63
Notes: fit(R^2)				

*** = α = 0.1; ** = α = 0.05; and * = α = 0.001 representing significance levels

The increased number of other crops cultivated by the farmers, was found not to affect the land allocated for cassava. If cassava was grown as food crop acreage decreased by 17.1% but this is not significant. Effect farmer's of education on cassava production was found to be positive but, was also not significant. Increase cassava yield by 1%, decreased acreage by 0.025% (at α=0.001). Effect of gender on cassava acreage was found significant (at α=0.1). Production of other crops by the farmer has a positive effect on cassava acreage, as similarly reported by Oleke *et al.* (2012) that, farmers in Eastern zone intercropped cassava and other annual crops with perennial crops to increase food security and income. If cassava is grown as food crop, there is decrease of total land allocated for cassava as there are other crops which supplement food supply in the household. This can also imply that if cassava is grown as a cash crop, the total area under cultivation will increase. In contrary, it was found that, increase in cassava yield decreased cassava acreage (11%). This may be attributed by lack of reliable market caused by insufficient market information and poor linkage among cassava stakeholders in the value chain as reported by Mkamilo and Jeremiah (2005).

Trading is an important economic activity after farming, and was also found to affect the proportion of particular landrace planted by farmers. Karumula *et al.* (2004) also reported that out of 39 banana cultivars grown; only 19 had high correlation of use and marketable cultivars were not the one most preferred by farmers for home consumption.

3.4 Conservation status of cassava landraces

Farmer's inventory of cassava cultivars was taken, during which farmers were asked to identify cassava varieties that were planted in their fields in large proportion and were termed as 'not threatened'. Farmers were also asked to identify landraces which had been grown in the past 30 years and above, and were no longer cultivated and termed as 'extinct'. There were landraces which were also popular in past years but are presently not grown in big proportion due to limited availability of planting material. These were recorded as threatened. The conservation status of each known cassava landrace was established based on availability of landrace (not threatened, threatened and extinct) in the study area and is summarized in Table 4.

Conservation status of landraces grown by farmers over the past 40 years indicated that there is a loss of cassava genetic diversity. Decrease in production and susceptibility to diseases have led to extinction of some important landraces. Introduction of new variety was not found to be the main reason for complete abandoning of some varieties rather than decreasing the proportion of particular landrace planted by the farmer. In contrary to that, Khatib et al. (2008) reported 66.7% of farmers in Tongwe (Muheza district) had completely abandoned planting some other landraces because of the introduction of variety *Kiroba*. However, there are landraces which have been kept by farmers for years even though not planted in big proportion. These varieties include Mahiza, Sufi and Cosmas.

A study done by Bellon (1996) [b] on maize farmers in Mexico, reported that farmers kept some landraces in small stand for conserving the seed for future use, even though it was not known exactly when this landraces will be useful.

Table 4: Conservation status of each known landraces

Not threatened (36.4%)	**Threatened (40%) (n=55)**		**Extinct (23.6%)**
Cosmas	*Barawa*	*Tenga tele*	*Agrikacha*
Kibanda meno	*Binti athuman*	*Tulia uolewe*	*Cheusi*
Kikombe	*Bwana mrefu*		*Hakungwa*
Kiroba	*Cheupe*		*Heya*
Magereza	*Kasese*		*Kabangi*
Mahiza	*Kasunga*		*Kichooko*
Mamosi	*Kibaha*		*Kitumbua*
Msenene`	*Kibangili*		*Kitunguu*
Mwarusha	*Kigoma*		*Mbega nyeupe*
Nyamkagile	*Makaniki*		*Mdidi*
Kilusungu	*Mbande*		*Mndunga*
Kiguu cha ninga	*Mbega*		*Mwarabu*
Mwanamke nyonga	*Mwasunga*		*Usimpe Juma*
Pushuu	*Mwekundu*		
Nyamato	*Mwalim hamis*		
Tandika	*Mzungu*		
Moshi wa taa	*Pamba*		
Mgeni	*Ponjoo*		
Msufi	*Semakange*		
Dihanga	*Sina wangu*		

Farmers also indicated the reasons for abandoning cassava landraces (Table 5). The response gives an insight into variety selection criteria by farmers and importance of cassava to the household.

Table 5: Reasons for abandoning or loss of landraces

Reason	Percentage (%)
Susceptibility to disease	53.5
Drought	23.2
Loss of good qualities	17.2
Introduction of new variety	6.1

Farmers were challenged with the storage of planting materials and conservation of good landraces for the next growing season, particularly during the long dry spell. For years, farmers have developed several ways of conserving planting material for the next planting season (Plate 1 and 2). These methods includes; planting a bundle of cassava stems under tree shade or along the edge of the farm where there is enough moisture. Ponds area is mostly preferred for conservation of planting material. Some farmers planted excess cassava plants which are harvested continuously until next planting season, where by the remaining plants are uprooted and prepared for planting. Famers with large cassava fields were found to be well knowledgeable with the conservation techniques and enough supply of planting materials during the season.

Plate 1. Conservation technique where by bundles of cassava stems are planted along the edge of the farm

Plate 2. Conservation technique where by bundles of cassava stems are planted under the tree

3.5 Utilization

Primary purpose of cassava production in the study areas was for home consumption as staple food except in Morogoro region, where maize was found to be a staple crop. Cassava was mainly grown for commercial purpose and sweet varieties were commonly found. Farmers grow a mixture of both short duration (early bulking) varieties like *Kiroba, Msenene* and *Nyamkagile* and long duration (late bulking) varieties like *Bwana mrefu, Dihanga* and *Kalolo* for purpose of food security. Some varieties were found to be grown for marketing. These varieties may not be necessarily consumed at home. Farmers considered culinary attributes such as taste, aroma and mealness in selection of cultivars for home consumption. Cultivars like *Sufi* and *Pusuu* are preferred for home consumption because of their soft texture and good taste, while *Kibandameno* was preferred for its high dry matter content and good aroma. Most farmers' process fresh cassava root into dried chips known as *makopa*, before consumption and also during preparation for storage.

Processing of cassava involved; peeling, drying (in heaps) for 3 to 4 days then slicing, drying and packing in bags for storage (Figure 4).

Cassava roots
↓
Peeling
↓
Heap drying for 3-4 days
↓
Scrapping off moulds
↓
Chipping
↓
Open Sun drying for one day
↓
Storing or milling to flour for home consumption

Figure 4. Common postharvest processing of cassava in the study area

Processing technology for cassava is well adapted and common product known as 'makopa' (dried cassava chips) is mainly produced and stored. Delay harvesting (piecemeal) was practiced as means of food preservation and conservation of planting material. However, this practice has limitations of root rot and lignification as reported in previous studies by Oluwole *et al.* (2007). Drying of fresh cassava in heaps is done to facilitate fermentation and decrease rate of dehydration so as to effectively remove cyanogen in dried chips (*makopa*). The process of fermentation combined with slow drying has been also reported by others to effectively remove cyanogen in dried cassava chips (Muzanila *et al*., 2000; Gidamis *et al.,* 1993).

Cassava was found second staple food and mainly consumed boiled or *futari* (boiled fresh cassava with coconut milk) and popular *bada* (cassava flour stiff porridge). Other method of cassava storage used by 34.6% of farmers was to leave cassava plants in the farm and harvest small portion for consumption (piecemeal). This method was mainly done for landraces that can store long in the soil and especially bitter varieties. These variety included *Kilusungu, Kalolo, Tandika*, *Dihanga* and *Bwana Mrefu*. Starch processing was found not common to the area except for Tongwe farmers (22.9%) in Muheza districts. Farmers at Tongwe were trained in starch processing by Sokoine University of Agriculture and IITA (International Research for Tropical Agriculture). However these farmers are faced with a problem of marketing due to poor quality of starch they produced thus low acceptability of their product by the processing industries like the textile industry.

5. Conclusion

Farmer's knowledge influence seed flow, management practices and utilization options in the traditional farming system. Farmers strive to increase diversity of their crops to meet their daily needs by improving production and increasing their income. Seed flow was found to be an important practice for maintenance of diversity and occurred during incorporation of new landraces or replacing lost landraces. Most of the cassava cultivars were indigenous to the place but some have been introduced in recent years.

The study has established that cassava is an important staple crop and source of income. Farmer's management of genetic resources involves different cassava landraces they keep in their farms and management practices they are subjected to. Diversity of cassava cultivars is a result of farmer's decision to maintain, discard or incorporate in their farming systems. Farmer's knowledge guides on- farm conservation of diversity and their farmer's decisions to conserve depend upon their preferences and landrace performance. We found that farmers are interested in landraces with contrasting traits that fit their uses this also influenced their decision to allocate land for cassava. It is important to relate farmer's decision making to the pool of landraces that they maintain. Therefore, role of farmers' practices in the genetic conservation cannot be undermined and should be taken into consideration during establishment of research strategies.

ACKNOWLEDGEMENTS

This work was funded by Tanzania's Commission of Science and Technology (COSTECH). The authors also wish to thank Mr. Komba, Mr. Nyarusi and Mariam Kilima for data collection.

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