Full Length Research Article

Yam landrace diversity and distribution in Basketo and Dera Malo Districts, Southwest Ethiopia

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Abstract

Smallholder farmers grow diverse crop landraces in their fields which contribute to the capacities of agricultural systems to adapt to environmental changes through maintaining broad genetic variations of crops, and there by allowing evolution of crops to continue. This study, therefore, was conducted on yam landrace diversity and distribution in two districts in South West Ethiopia, namely Basketo and Deramalo districts of which eight yam growing communities (four from each district) were included with the purpose of finding out the diversity and distribution of yam farmers' landraces on cultivation in the study area. 248 yam farmer informants were selected for collecting data through semi-structured interviews, focus group discussions, and yam landrace count on the bases of field observations. A total of 25 yam varieties were recorded with a mean of 8 at a household level. Invariably in the eight study communities, most of the varieties were cultivated in small areas by few households, depicting serious genetic erosion of yams in the communities. There was also a significant difference among the study sites in the mean yam landrace richness and diversity at 95% level of significance ($p<0.05$). In addition, the study showed that there is a trend of gradual withdrawal of the cultivation of some yam landraces due to various reasons. Hence, interventions that align individuals' and society's interests to maintain the viability of on-farm conservation of yam landraces may be needed.

Keywords: distribution; diversity; farmers' yam landraces richness; yam

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1.Introduction

Numerous studies highlighted the role of agro-biodiversity in providing enhanced nutrition (Yenagi et al., 2010, Pascual et al., 2011), environmental benefits (Perrings et al., 2006; Jackson et al., 2007), improved livelihoods for small-scale farmers (Keatinge et al., 2009, Jackson et al., 2010) and increased resilience to climate change (Padulosi et al., 2011; Ortiz 2011a; Guarino and Lobell, 2011). There is the erosion of the genetic resources of neglected and underutilized crops like yam (Dioscorea spp.) as they are replaced by improved cultivars or cash crops (Adoukonou-Sagbadja et al., 2006).

The conservation of diversity of crop species has been a worldwide concern for many decades due to the worry that a great amount of this diversity would disappear with agricultural and economic development, that is, genetic erosion (Brush, 2004; Gepts, 2006; van de Wouw et al., 2010).

It is, therefore, necessary to document the current diversity and distribution of crop landraces to help develop efficient strategies in the conservation of crop species and respective landraces (IPAGRI, 2002; Gruère et al., 2009). In order to promote yam landraces, conservation and increase in production in the study area as well as in Ethiopia, it is necessary to understand the current status and distribution of yam genetic diversity maintained *in situ* by the farmers. The main purpose of this study, therefore, is to study the current diversity and distribution of yam landraces in eight communities in Basketo and Deramalo districts of the South West Ethiopia in terms of yam landrace richness.

2.Materials and Methods

2.1 Description of the study areas

Basketo and Deramalo are the two study areas selected for this study. Basketo is a district in Southwest Ethiopia with altitudes ranging from 700 to 2200 masl. Laska, the main town of Basketo, is 581 km away from Addis Ababa and located at 06^0 18'N, 36^0 37'E. It is bordered in the south and west by the Debub Omo zone, and in the north and east by the Gofa Zone. Based on the agro-ecological zone classification scheme of MoA (2000), Basketo falls into the tepid to cool sub-humid mid-highlands subzone, which is characterized by fertile soils and a conducive climate for plant and animal growth (Feleke et al., 2016). The mean annual rainfall of the area is 1376 mm with a 1578 mm maximum which exhibits a two-peak pattern. This district has a total population of 56,689, of whom 28,532 are men and 28,157 women (CSA 2007).

Deramalo is also one of the districts in the southwestern Ethiopia. The administrative town, Wacha is about 480 km from Addis Ababa, the capital city of Ethiopia. Deramalo is part of the Gamo Zone, bordered with different districts such as Bonke in the southeast, Kemba in the southwest, Zala in the west, Kucha in the north, and Dita in the east. Wacha, which is the administrative town of Deramalo district, is located at 05^0 17’N, 36^0 37’E. Daramalo district has a total population of 81,025, of which 41,618 are male and 39,407 are female; 3,220 or 3.97% of its population are urban dwellers and the remaining 96.03% are rural dwellers (CSA, 2007).

Basketo and Deramalo districts were selected among the yam cultivating areas in Southwest Ethiopia, after a reconnaissance survey. The study kebeles (sub-districts or communities) were selected purposively based on the results of a reconnaissance survey as well as information obtained from different key informants. A total of eight kebeles from the study area which are four from each district were selected. These included Wadha Balantsa, Sasa, Dabtsa Dalgisa and Doko Chere kebeles from Basketo district, Malo Ezo, Malo Mache, Menana Abaya and Menana Selo kebeles from Deramalo district.

2.2. Sample size determination and Sampling techniques

Proportional sample size determination was used to get 248 informants from the eight study sites/kebeles and to accommodate for the differences in numbers of households in each study site/*kebele*. Then sampling interval was calculated that varied for the different kebeles as a function of their respective household size (Table 1), following the method indicated by Kotharis (2004).

Table 1. The eight study sites/kebeles with their total household numbers (THHs) and sampled household (SHHs)numbers and sampling intervals (SI)

Kebele/district			
Basketo District			
Wadha Balantsa	420	25	17
Doko Chare	500	30	17
Sasa	470	28	17
Dabtsa Dalgis	570	35	17
Deramalo District			
Malo Ezo	600	34	18
Malo Mache	545	30	18
Menana Abaya	675	37	18
Manana Selo	480	29	17
Total	4260	248	

2.3 Data collection

Semi-structured interview was the major tool used to collect data from the informants. Moreover, field observations of household yam farms were made for data on farm landrace richness per household. Focus group discussions were also held with key informants, local leaders, elders, peasant association leaders, and agricultural extension workers.

2.4. Data analysis

Data was analyzed using descriptive statistical method and summarized in tables as percentages, means, and standard deviations. Shannon-Wiener Index, H', for yam landraces diversity (Shannon, 1949) and richness of each study site/*Kebele* were also used. In addition, age and educational levels of household heads, were correlated with landraces diversity per household using Pearson correlation coefficient.

3. Results

3.1 Socio-demographic variables

Among the respondents, 68.75% of households were male-headed and 31.25% were female-headed farm families, with a mean age of 46.5 years. Around 46.7% of respondents were illiterate but 14% were informally educated and were also able to read and write. Forty six respondents (57.5%) were greater than 50 years old and 14 respondents (17.5%) were 20 to 30 years old and 20 respondents (25%) were between 31 and 49 years old. The minimum household size was 1 and the maximum was 9 with 23% of the farmers interviewed having an average household size of 4. 35% of interviewees had basic school education, 17.5% had primary education, and while 22.5% of farmers had high school education and 25% had no formal education (Table 2). Most of the farmers (74%) interviewed were engaged in farming for more than 15 years.

Table 2. Informants profile of the study area

		Percentage (%)
Sex		
Male (M	170.5	68.75
Female (F)	77.5	31.25
Age Category		
20–30	43.4	17.5
31–49	62	25
50>	142.6	57.5
Educational Background		
No education	**62**	**25**
Basic education	86.8	35
Primary education	43.4	17.5
High School	55.8	22.5

There was a strong linear Pearson's correlation and ordinary least square regression between age and yam landrace knowledge (number of yam landraces enumerated by the respondents), $r = 0.93$, $r^2 = 0.87$, respectively *for* 95% confidence level, $P<0.001$ (Figure 1).

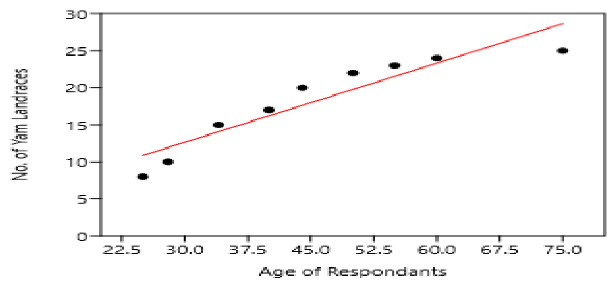

Figure 1. Ordinary least square regression between age of respondents and number of yam landraces mentioned.

1.2 Yam Landraces varieties and Richness and Diversity

Yam landraces varieties and richness and diversity were studied in the two districts. Based on the interview, 25 yam varieties were recorded in the study area. The study showed that there was a significant difference between the two study districts in mean landrace richness, $t = 8.2596$, $P<0.001$, and mean Shannon diversity $t = 7.8699$, $P<0.001$ (Table 3, Figures 2). The study also showed that the yam farmers of Basketo district had a trend of maintaining more on-farm yam landrace richness than the Dara Malo yam farmers. The former farmers even had the practice of bringing yam wild relatives and maintained them on-farm. Many traditional agroecosystems are located in centers of crop diversity, thus containing populations of variable and adapted land races as well as wild and weedy relatives of crops (Harlan, 1965). Food and Agriculture Organization of the United Nations (FAO) (2010) wrote that while genetic erosion certainly has occurred worldwide, a large amount of crop diversity is still retained in developing countries by smallholder farmers (van de Wouw et al., 2010). According to Brush (2004), Jarvis et al. (2008), and Zimmerer (2010), this is particularly true for crops in their centers of domestication and diversity where farmers continue to grow landraces. A salient feature of traditional farming systems is their degree of plant diversity in the form of polycultures and/ or agroforestry patterns (Clawson, 1985).

Table 3. Mean landrace richness, Mean Shannon diversity, and Percentage (%) in the study Kebeles

Kebele/district			
Basketo District			
Wadha balanta	25	5	.57
Doko Chare	21	6	.76
Sasa	18	4	.65
Dabtsa Dalgisa	17	3	.95
Deramalo District			
Malo Ezo	10	5	.03
Malo Mache	8	6	.62
Menana Abaya	7	3	.92
Menana Selo	9	6	.32

MLR, mean landrace richness, and MShD, Mean Shannon diversity

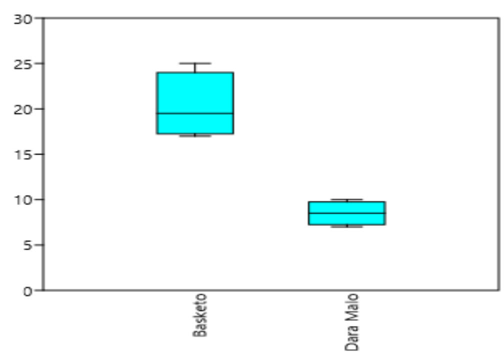

Figure 2. Box plot showing variations in mean yam landrace richness between Basketo (left) and Dera Malo (right)

Based on the ranges of yam landrace richness, four major classes were formed to see the overall pattern of diversity and distribution of yam landraces. The results showed that the lower household frequency classes had higher percentages and the higher household frequency classes had lower percentages. Accordingly, from the total households, only less than 5 household frequency classes had the highest percentage which is 63.2% followed by 20% for 11-15 household frequency classes and 9.6% for 16-25 household frequency classes (Figure 3). This result may indicate a decreasing trend of maintaining high on-farm landrace diversity which again may be related to farmers' withdrawal from some landraces due to various reasons. Different authors have written that traditional smallholder farmers do have reasons that force them to abandon the cultivation of certain crop landraces (Mauricio et al., 2015). Development and the increasing reach of modern value chains may make traditional value chains linked to niche markets to become uncompetitive, leading to less commercial opportunities for marketing diverse varieties or products derived from them (Tisdell & Seidl, 2004; van de Wouw et al., 2010). Availability of new products may compete with products derived from traditional crops or local varieties in terms of price and convenience (Andersen, 2010), which together with changes in taste, or an increased perception that traditional crops and varieties are associated with poverty or low social status, may reduce their appeal (Keller et al., 2005).

Figure 3. Household yam landrace richness classes

3.3 Variations in yam landrace richness among study kebeles

All farmers cultivated at least more than three varieties of yam. The mean number of yam varieties per households varied among the sampled kebeles as well as the two districts. The mean number of yam varieties per household in Basketo district was higher than that of Dara Malo District, which was 12 and 6, respectively. The number of yam varieties (richness) at the level of households varied from 4 to 25. The largest range in household level landrace richness was recorded at Wadha Balantsa (6 and 25) while the smallest range was recorded in Mannana Abaya (4 and 10). The mean value of the landraces of all households was 9.2 while the standard deviation was 4.33. Generally, the mean landrace richness of Basketo district was higher than Deramalo district. The latter had narrower range of landrace variations maintained on-farm and had a few selection criteria like taste, color, short harvesting time and secondary harvest. Test for equal means (One way ANOVA), in mean yam landrace richness among the sampled kebeles also showed a significant variation in yam landrace richness, One Way ANOVA, $F=13$, $P<0.001$, which may explain the different patterns of crop landrace distribution (Gepts, 2006).The wide range of variations between the two districts as well as the study kebeles may be due to several reasons like the cultivation of a diverse set of landraces with an associated knowledge base and the existence of multiple uses and preparations, usually linked with particular cultural preferences (Zimmerer, 2010; Brush *et al*., 1995).

The mean number of occurrences among the different yam landrace along the sampled kebeles varied significantly, $t= 9.1237$, $P<0.0001$. The mean number of occurrences among the different yam landraces is 45.875 ± 10.255 at 95% confidence interval. Gepts (2006) wrote that there is usually unequal distribution of crop landraces in their centers of origin. Unequal distribution and abundance of yam landraces in the study area reflects variations in their relative importance to households and provides a strong evidence for the presence of farmers' selection. This result, to some extent, is in line with the findings of (Gepts, 2006; Belon et al. 1997). For example, Gepts (2006) found that any crop, infra-species diversity is unequally distributed around the world and is usually concentrated in its centers of diversity, which often coincide with the crop's center of domestication. The existence of different (variety) of yam landraces in different levels of diversity in the study area may largely depend on environmental factors like elevation, climate, availability of sucker, good management and presence of organic fertilizer (animal dung). Belon *et al*. (1997), wrote that smallholder farmers maintain diverse landraces of a crop because they play multiple roles in their lives and livelihoods, addressing different needs and constraints, and providing a range of benefit.

The results revealed that the variations in the composition of yam landraces between pairs of locations (beta diversity) ranged between 0.33 and 0.82 with a mean and standard deviation of 0.51 and 0.13, respectively. The highest calculated value of Beta diversity index was between Wadha Balantsa, and Malo Ezo which was 0.82 (Table 4). This means that these kebeles shared only 18% of the landraces and 82% were dissimilar. On the other hand, the smallest beta diversity was between Doko Chare and

Manana Selo with 0.33 followed by between Wadha Balansa and Manana Selo with 0.38. The highest beta diversity was observed between kebeles of different districts and on the other hand the smallest was between kebeles of the same district. This result is more or less, similar with other studies elsewhere in the world that farmers influence the diversity and distribution patterns of crop landraces through their local knowledge, preferences, practices, decisions about the alleles and genotypes that pass from one generation to the next and result in variations in landraces spatial distribution and their exposure to varying biotic and abiotic factors (Brush, 2004; Bellon, 2009; Gepts, 2006; Labeyrie *et al*., 2014; Vigouroux *et al*., 2011).

Small value of Beta diversity indicates high similarity in the composition of yam landraces, because as the beta diversity index approached to zero, the sites under concern become more and more similar, and with zero they become identical in composition. The low variations in the landraces composition among kebeles of the same district may be explained as the effect of distance to happen in close locations having similar exposures and responses to similar environmental factors, like temperature, altitude, rain fall, and variations in farmers' preferences to the type of yam landrace cultivated as well as cultural inconsistencies.

Table 4. Beta diversity index (β) (dissimilarity values for yam landraces composition of the *Kebeles* (WB=Wadha Balansa, DD = Dabtsa Dalgisa, Sasa =SA, Doko Chare = DC, Malo Ezo = ME, Manana Abaya = MA, Malo Mache = MM, Manana Selo = MS).

	WB	**DD**	**SA**	**DC**	**ME**	**MA**	**MM**	**MS**
WB	0	0.52	0.56	0.36	0.64	0.82	0.71	0.38
DD	0.52	0	0.4	0.42	0.73	0.60	0.71	0.46
SA	0.56	0.4	0	0.46	0.70	0.70	0.67	0.4
DC	0.36	0.42	0.46	0	0.65	0.65	0.63	0.33
ME	0.64	0.73	0.70	0.65	0	0.5	0.71	0.6
MA	0.82	0.6	0.70	0.65	0.5	0	0.71	0.73
MM	0.71	0.71	0.67	0.63	0.71	0.71	0	0.57
M S	0.38	0.46	0.40	0.33	0.60	0.73	0.57	0

The study also revealed that there is a gradual declining trend in yam landrace diversity in the study area. The reasons for this may be varied. Kenyon and Fowler (2000) wrote that the genetic erosion on-farm are due to the introduction of new varieties, loss of farms, changes in farmers' practice and market demand. Climate change, biotic and abiotic stresses are the other causes of genetic erosion and cultivation of few accessions in small areas.

4. Conclusions

This study presented the diversity and distribution of yam landraces in Basketo and Deramalo districts. The result showed that there was a total of 25 named yam landraces from 248 households that were selected from the eight *Kebeles* in the study area. An average of 9.2 yam landraces was grown in each farm. The result from this study also showed that richness and diversity of yam landraces were different between the two districts and the study *Kebeles*. There was variation in the composition of yam landraces among the two districts and among the different kebeles. There is a general trend that farmers abandon the cultivation of some yam landraces. On the other hand, there is an observed need to bring and domesticate wild relatives of yam crops. Hence, farmers should be assisted to be aware of the need to maintain all landraces and they should also be given some support or compensations for the costs of maintaining them.

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Conflict of interest

There was no any conflict of interest during sampling, laboratory works, data analysis, and manuscript preparations. All the necessary reference sources were cited and duly acknowledged.

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