Vol. 11(1), pp. 1-7, January 2019
DOI: 10.5897/IJBC2018.1247
Article Number: 8E37E1A59787
ISSN 2141-243X

http://www.academicjournals.org/IJBC

ACADEMIC JOURNALS
expand your knowledge

International Journal of Biodiversity and Conservation

Full Length Research Paper

On farm diversity of barley landraces in North Western Ethiopia

Daniel Tadesse* and Tazebachew Asres

Department of Plant Sciences, College of Agriculture and Environmental Sciences, University of Gondar, Ethiopia.

Received 8 November, 2018; Accepted 17 December 2018

Barley is one of the major cereal crops grown in Ethiopia. The diversity of barley landraces kept for generations in Ethiopia is nowadays subject to genetic erosion. This is true in North Gondar highlands of the country as well. This research was therefore initiated with the aim of studying the farm diversity status of barley landraces in Debark, Dabat and Wogera districts. A total of 180 randomly selected farmers from six villages were surveyed with a proportion of 30 farmers/village. Ecological models were employed to analyze the level of diversity. Genetic erosion models were employed to estimate the level of genetic erosion over a ten-year period of time. A total of 24 landraces were described by farmers of the studied sites. Of these, 18 of them are still under cultivation although their area coverage is declining from time to time. The landraces *Abat gebs*, *Nech gebs* and *Tikur gebs* were found to be the most common and widely grown. Debark district was found to have the highest richness (Margalef=2.45; Menhinick=1.43) followed by Wogera and Dabat districts. With regard to evenness as a measure of Shannon diversity index, Wogera district (E=0.85) showed the highest diversity followed by dabat (E=0.83) and debark (E=0.79). Simpson's diversity index (D) also revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52). The landraces *Demo kises*, *Goreneje*, *Chankirme*, *Gabieaswelik*, *Amedo* and *Gero tal* were found to be out of production in the last ten years and probably eroded. Genetic erosion and genetic integrity over ten years (2006-2016) was found to be 25 and 75%, respectively. The name given to landraces studied was found to be associated with certain characteristics or situations. Thus, policy makers and researchers should give attention to conservation of landraces of barley (*Hordeum vulgare* L.) for better use of genetic resources.

Key words: On-farm diversity, genetic erosion, barley, landrace.

INTRODUCTION

Ethiopia is a country renowned for the diversity of its native barley types and is recognized internationally to harbor valuable barley genetic resources. With microsatellites derived from nuclear and chloroplast DNA, a significant genetic diversity and distinctiveness of Eritrean and Ethiopian barley lines was found (Orabi et al., 2007). Barley (*Hordeum vulgare* L.) is one of the most important cereal crops, mainly grown by smallholder farmers at mid- and high-altitudes in North West Ethiopia, predominantly between 2200-3000 m.a.s.l. (Asmare et

*Corresponding author. E-mail: kaleabfather@gmail.com.

al., 1998). Hence, there can be a typology of farm cropping systems that may influence conservation of barley landraces.

There is growing interest in conservation of genetic resources in the agro ecosystem in which they have evolved; that is, *in-situ* conservation (FAO, 1996). This is especially important in areas of crop domestication/origin, where diversity of genetic resources is concentrated and where farmers maintain not only the landraces of ancestral crop populations, but also the human knowledge and behavioral practices that have shaped this diversity for generations (Bellon and Taylor, 1993). Understanding the diversity within a crop in an area means understanding the people who grow it, just as much as understanding the climate, the soil of the region and distribution of wild relatives (Guarino, 1995). This is because: the pattern of diversity in crops is the result of an interaction between the genetic make-up of the plants, the abiotic and biotic environmental factors as well as human selection and management. A hypothesis on the local agriculture features and the drivers and mechanisms of differentiation among farming systems, such as biophysical and socio-economic conditions, will be tested with statistics.

The bases for the currently grown improved varieties of crops are landraces well managed by farmers for millennia of generations. These landraces have important traits like resistance to biotic and abiotic stresses, which help to boost production and productivity through direct selection, hybridization with each other as well as gene transfer. Nowadays, the landraces are eroding from time to time and we are losing their diversity especially in crops where Ethiopia is either a center of diversity or origin. One of the crops is barley, which is grown widely by Ethiopian farmers mostly in the mid- and high-land areas.

Although the Northern Gondar highlands are potential barley production areas and harbor great diversity of land races, there is no well-documented study about the diversity of barley landraces. The present study was therefore initiated in order to document the diversity of barley landraces through various diversity index models, and to estimate the extent of genetic erosion through genetic erosion models in the North Gondar highlands of North Western Ethiopia.

MATERIALS AND METHODS

Description of the study areas

Six villages of Debark, Dabat and Wogera, two in each district, were studied. These districts are the major barley producing areas of North Gondar highlands. The villages were *Adisgie Miligebsa* and *Gomia* from Debark, *Woken* and *Talak mesik* from Dabat and *Daber Lideta* and *Kossoye* from Wogera. Although the geographic coordinates, soil physical and chemical characteristics of these villages vary, the agricultural cropping systems and also having high potential and large area coverage in barley production are marks of similarity among the six villages. There was no similar study that could be used as a baseline in the area.

Research design

The design consisted of three stages. In the first stage, three study districts were purposively selected from the potential barley producing districts of North Gondar zone in consultation with North Gondar Zone department of Agriculture. In the second stage, two villages were purposively selected from each district in consultation with district agricultural experts with the major criteria being higher importance of barley in terms of area coverage. In the third stage, 180 respondent households were selected and interviewed from the six villages, each with 30 farmers. Women household heads and elders were purposely involved to ensure good coverage of diversity in knowledge.

Vernacular names

Farmers in the study area give names to varieties of barley by observing peculiar traits like quality, yield, color of seed, size of seed, number of rows, season of planting, maturity and origin to distinguish one another. The landraces planted were identified, named and described by the farmers.

Ecological models

Ecological models were employed to analyze the level of diversity. The models have been adapted on species diversity (Magurran, 1988). Magurran defined species diversity as consisting of the number of species (richness-R) and how equally abundant the species are (evenness-E). Margalef's, Menhinick's, Shannon and Simpson's diversity indices were employed using landraces as species (Magurran, 1988).

Landrace richness

Landrace richness (inter-varietal diversity) among the three districts was compared by using Margalef's index (D_{Mg}) and Menhinick's index (D_{Mn}) as follows:

$$D_{Mg} = {}^{(L-1)}/_{\ln C} \qquad D_{Mg} \geq 0$$

$$D_{Mn} = {}^{L}/_{\sqrt{C}} \qquad D_{Mn} \geq 0$$

where L refers to the number of landraces in each district, while C designates the number of citations for each landrace.

Shannon Diversity Index (H)

$$H = -\sum_{i}^{n} pi \ln pi \quad Pi \geq 0$$

It is estimated as

where *pi*, the proportional abundance of the i^{th} landraces = (ni/N).

The evenness (E) as measure of the Shannon diversity index is calculated as follows:

$$E = {}^{H}/_{\ln L}$$

Simpson's diversity index (D)

Simpson's index (D), an index commonly used to measure spatial diversity. The frequency of occurrence of each farmer variety cited in the six villages was calculated and presented as cited by farmers. The index is constructed from the number of varieties occurring in a location, and data was compiled from the households across study villages. Its formula is:

$$D=\sum_{i=1}^{s} pi2$$

The proportion of variety i relative to the total number of varieties (pi) was calculated and squared. The squared proportions for all the species were summed, and subtracted from 1. The derived statistics 1 - D expresses the abundance and represents the probability that two individuals randomly selected from a sample will belong to different genotypes. The value of this index ranges between 0 and 1, the greater the value, the greater the sample diversity.

Genetic erosion models

Temporal diversity (rate of change over time) of barley landraces over a period of ten years were assessed in this study based on farmers interview and focus group discussion between the year 2006 and 2016. Genetic integrity and genetic erosion were calculated to assess the pattern of temporal diversity over 10 years (from 2006-2016) and to estimate the level of genetic erosion.
Genetic integrity (GI) and Genetic erosion (GE) was estimated as given by Hammer et al. (1996).

$$GI_{\%} = (C_{Y2}/C_{Y1}) \times 100$$

where *Y1* refers to number of landraces collected in the initial year (first collection mission) and *Y2* refers to the number of landraces collected in the second collection (second collection mission).

$$GE_{\%} = 100\% - GI$$

The data collected was analyzed using statistical package for social sciences (SPSS Version 16) computer program and various descriptive statistics and mathematical methods like mean, percentages and various analytical methods were used based on the objectives of the study.

RESULTS AND DISCUSSION

Distribution of barley landraces

Documenting farmer-named varieties is important from the genetic resources conservation and utilization point of view, as the names farmers give to varieties is the unit that farmers manage and select over time. A total of 18 barley landraces were recorded in the study districts, which vary in maturity, yield potential, stress tolerance, end-use qualities, and other agronomic traits. The distribution of these 18 barley landraces varied across the districts; that is, a landrace rare in one village was popular in another. As a result, a given landrace was registered in more than one distribution class. There were six landraces specific to study sites in each of Wogera and Debark districts, while no single landrace was specific to Dabat district. The most common and widely grown landraces listed by farmers across all study districts were *Abat gebs*, *Nech gebs* and *Tikur gebs* (Table 1).

In Debark district, 11 landraces comprising 59 citations were recorded. In this district, only four landraces out of the eleven landraces recorded were found to be popular among many households (79.7%). These are *Tegedie belga*, *Nech gebs*, B*elga* and *Abat gebs*. In this area, three landraces namely *Shewa gebs*, *Tikur gebs* and *Akiya* were cited by one farmer each that showed their rarities in the district. Except *Tikur gebs*, the other two rare landraces were only cited in this district indicating these two landraces are becoming endangered to be lost (Table 1).

In Wogera district, 10 landraces comprising 60 citations, were recorded. In this district, only two landraces (*Abat gebs* and *Andita*) were cited by more than half household members (53.3%) showing the popularity of these landraces in the area. In this area, two landraces namely *Tikur gebs* and *Dinbil nech gebs* were cited by one farmer each showing their rarities. Of these rare varieties, *Dinbil nech gebs* is recorded only in this site. In this area, a variety *Teklie gebs* was named after the selector farmer "Teklie," and it was cited only in this district by six farmers (Table 1).

In Dabat district, 6 landraces comprising 59 citations were recorded. In this district, only two landraces, namely *Netela belga* and *Nech gebs*, were cited by more than half of the household members (66.1%); showing the popularity of these landraces in the area. The landrace *Bozie belga* was only cited by one farmer in this district. All the six landraces found in this district were also cited by other districts showing absence of a specific landrace in this district (Table 1). This district is located between Wogera and Debark districts and is found relatively in a lower altitude than the other two. This might be the reason why a large number of landraces were not recorded, since barley landraces are mainly found in higher altitude areas. The landraces recorded in the study districts are purposely maintained to address various needs of the farming community. Similar results were noted for the reason why farmers kept many landraces of barley by Eticha et al. (2008) and Shewayrga and Sopade (2011) in central Ethiopia and north eastern Ethiopia, respectively.

Area coverage, production and productivity of landraces

The area planted, yield obtained and productivity of

Table 1. List of landraces recorded along with diversity estimate.

Debark		Wogera		Dabat	
Variety	**Frequency**	**Variety**	**Frequency**	**Variety**	**Frequency**
Abat gebs	5	Abat gebs	15	Abat gebs	6
Nech gebs	13	Nech gebs	7	Nech gebs	13
Tikur gebs	1	Tikur gebs	1	Tikur gebs	5
Bozie belga	2	Weremenie	4	Weremenie	8
Netela belga	2	Semeno	2	Bozie belga	1
Shewa gebs	1	Andita	17	Netela belga	26
Tegedie belga	20	Awura gebs	4		
Shegie gebs	2	Dinbil nech gebs	1		
Akiya	1	Derg gebs	3		
Belga	9	Teklie gebs	6		
Marwey	3				
Diversity Indices					
Number of landraces (L)	11		10		6
Number of citations (C)	59		60		59
Shannon Diversity Index (E)	0.79		0.85		0.83
Margalef's Index (D_{Mg})	2.45		2.20		1.23
Menhinick's Index (D_{Mn})	1.43		1.29		0.78

barley landraces was recorded and presented (Figure 1). The largest area share is covered by *Nech gebs*, followed by *Netela belga*, *Abat gebs* and *Tegedie belga* (Figure 1a). However, the yield obtained in *Nech gebs* is lower than *Netela belga* and followed by *Abat gebs* and *Tegedie belga* (Figure 1b). With regard to productivity of the barley landraces in a given area, the majority of the landraces have similar results with the more productive landrace being *Shegie gebs* followed by *Dinbil nech gebs*, *Akiya* and *Weremenie* (Figure 1c). This showed landraces with the largest area share were not found to be productive per unit area indicating farmers main criteria to grow certain landraces over others is not solely based on yield advantage rather combination of various attributes.

Variety diversity estimation

Diversity estimates, based on the number of landraces collected (richness), showed Debark area having the highest richness (Margalef = 2.45; Menhinick = 1.43) followed by Wogera (Margalef = 2.20; Menhinick = 1.29). Dabat was found to be less diverse in terms of a number of landraces collected in this study (Margalef = 1.23; Menhinick = 0.78) (Table 1). Diversity estimated based on evenness index (Shannon diversity index) on the other hand showed highest diversity in Wogera district (E=0.85) followed by dabat district (E=0.83) and Debark district (E= 0.79) (Table 1). The highest evenness found in Wogera and Dabat districts were attributed to the abundance of the majority of landraces across the villages.

Simpson's diversity index

The occurrence of landraces in one or more locations is presented in Table 2. If a landrace is sampled in one site with higher frequency, that variety is locally common and the diversity value will be 0, or near to 0. If a variety exists in two or more sites, even if the frequency is low, the Simpson's index will be higher. The Simpson's diversity index (D) revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52) in the study sites (Table 2). *Nech gebs* and *Abat gebs* were found to be common and widely distributed in all districts and were cited by 33 and 26 farmers, respectively. *Tikur gebs* on the other hand was only cited by seven farmers though it was distributed in the three districts. The landraces *Weremenie* (0.48), *Bozie* (0.33) and *Netela belga* (0.14) were cited by farmers in two districts each. The remaining twelve landraces (66.67%) were reported to be common but specific to only one district each; that is why their Simpson's diversity index was 0 (Table 2).

Temporal diversity pattern and genetic erosion

For the last ten consecutive years, between 2006 and

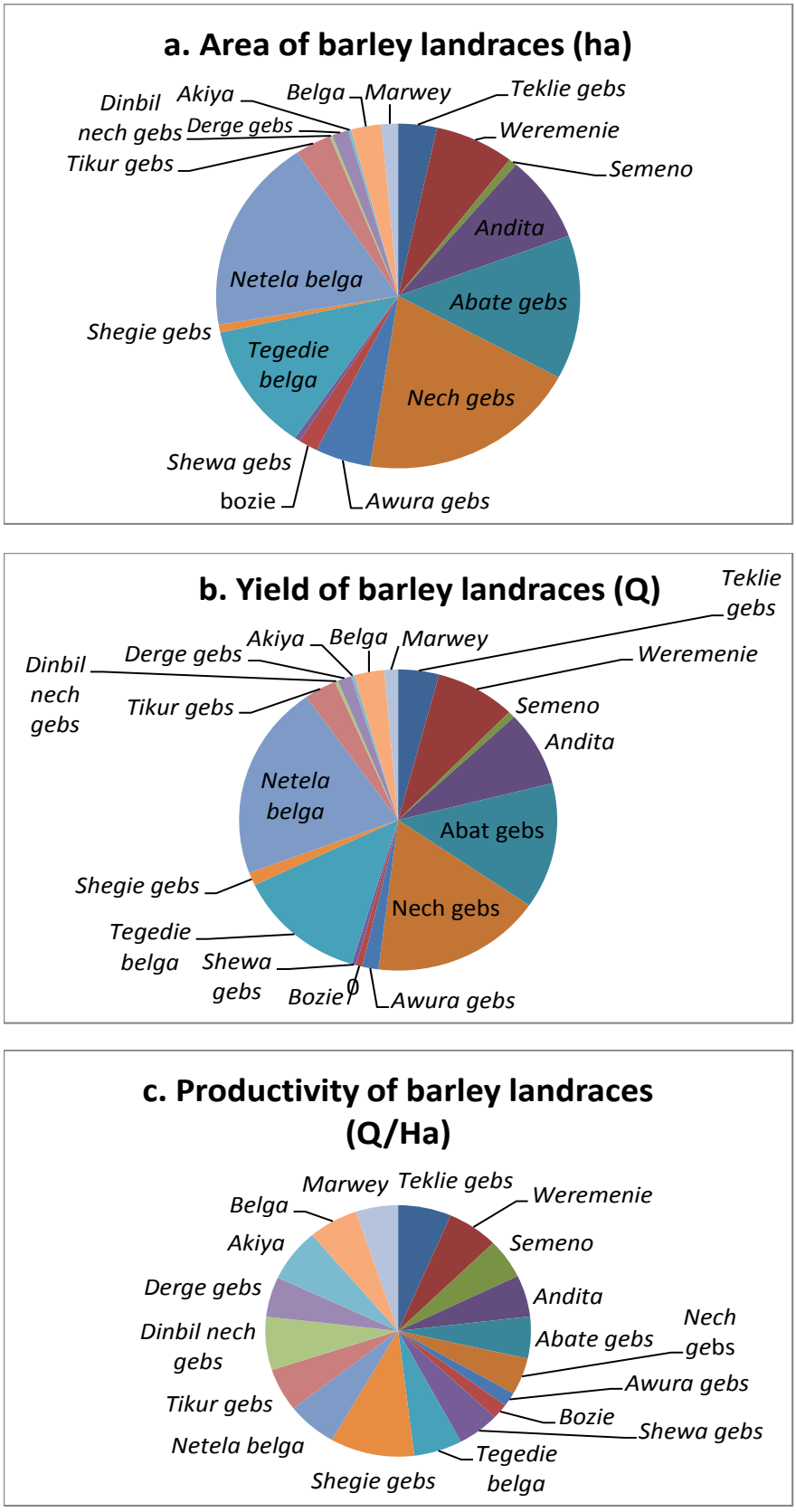

Figure 1. Area, yield and productivity of barley landraces in north Gondar highlands.

Table 2. Occurrence of landraces in each district according to Simpson's Index (D).

Landrace name	No. of farmers who cite the landraces			Cited farmers	Simpson index
	Wogera	Dabat	Debark		
Teklie gebs	6			6	0
Weremenie	4	8		12	0.48
Semeno	2			2	0
Andita	17			17	0
Abat gebs	15	6	5	26	0.6
Nech gebs	7	13	13	33	0.66
Awura gebs	4			4	0
Bozie		1	2	3	0.33
Shewa gebs			1	1	0
Tegedie belga			20	20	0
Shegie gebs			2	2	0
Netela belga		26	2	28	0.14
Tikur gebs	1	5	1	7	0.52
Dinbil nech gebs	1			1	0
Derg gebs	3			3	0
Akiya			1	1	0
Belga			9	9	0
Marwey			3	3	0

2016, it was reported that there were 24 barley landraces in the study districts, which were under production. But during the study time (2016), only 18 landraces were found under production, which means six landraces were missing from the recent study. These missed landraces were named as *Demo kises, Goreneje, Chankirme, Gabie aswelik, Amedo* and *Gero tal*. Based on the model of genetic integrity and genetic erosion, the genetic integrity was about 75% and the genetic erosion was 25%. This means 75% of the landraces present in the last ten years are still under production and the remaining ones were lost. Similar results in many other crops have been reported; i.e., farmer varieties are rarely seen in the fields (Girma, 2014).

Vernacular names

The different landraces planted in the study areas were identified, named and described by the farmers. Studies on other crops showed that vernacular names and farmers' descriptions of landraces can relate to formal scientific classifications (Teshome et al., 1997). The varieties *Weremenie, Semeno, Shewa gebs* and *Tegedie* have got their name based on from where they came from in the country. The varieties *Nech gebs*, *Tikur gebs* and *Shegie gebs* got their name based on the colour of their seed. The variety *Derg gebs* is given its name since it came to the study area during the regime of *Derg*. The variety *Teklie gebs* has got its name from the farmer selector named *'Teklie'*. The farmer varieties identified, number of rows they have and their meanings are listed in Table 3. The barley landraces studied in the north Gondar highlands were entirely different (at least in name if not genetically) from similar studies made earlier by Eticha et al. (2008) and Shewayrga and Sopade (2011).

Conclusions

This research was conducted to assess on farm diversity status of barley landraces. The numbers of landraces before a decade in the study districts were reported to be 24. However, in 2016 eighteen landraces were being grown on small plots of land. The landraces *Demo kises*, *Goreneje*, *Chankirme*, *Gabieaswelik*, *Amedo* and G*ero tal* were lost. The estimated loss accounts for 25% and the level of genetic integrity (GI) was 75%. Of these 18 cultivated landraces, *Abat gebs*, *Nech gebs* and *Tikur gebs* were found to be the most common and widely grown landraces.

Debark district was found to have the highest richness, followed by Wogera and dabat districts. With regard to evenness on the other hand, Wogera district showed the highest diversity followed by dabat and debark. Simpson's diversity index revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52). The name given to landraces studied was found to be

Table 3. Vernacular names and their meanings of barley landraces grown in North Gondar highlands.

Name	No. of rows	Meaning of variety name
Teklie gebs	Four	Named after the farmer selector, Teklie (probably selected from malt barley)
Derg gebs	Six	Comes during the regime of Derg
Woremenie	Two	Black seeded coming from Wollo
Semeno	Four	Comes from Northern Ethiopia
Andita	Six	Uncomparable in yield and quality /best/
Abat gebs	Six	Comes from early ancestral fathers
Nech gebs	Six	White kernel
Awura gebs	Four/Six	Big seeded and high yielder
Shegie gebs	Six	White kernel and attractive color
Netela belga	Two	It has a single row and grown two times a year
Shewa gebs	Four	Comes from Shewa
Akiya	Two	When touched by both hands after roasted, the cover easily separate from the seed specially used for *kolo*
Tikur gebs	Four/Six	Black (tikur) color of the barley grain
Bozie belga	Two	Sown lately
Marwey	Six	It is a mixture
Belga	Four	It is mixed and mature early
Tegedie belga	Six	Comes from a place called Tegedie
Dinble nech gebs	Four	Meaning not known

associated with certain characteristics or situations. In conclusion, the genetic resources will be used for meeting future food needs and social benefits for the world's rapidly growing human population. Therefore, attention should be given to on-farm conservation and enhancement of farmers' varieties. Thus, policy makers and researchers should give attention to conservation of landraces for better use of genetic resources.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This study was financed by the University of Gondar and we thank the institution for this. The assistance of the three districts' agricultural offices is highly appreciated. The farmers of the six villages deserve gratitude for giving their valuable information.

REFERENCES

Asmare Y, Alemu H, Alemayehu A, Melkamu A, Tessema Z, Berihane A, Halima H (1998). Barley production practices in Gojam and Gondar. In Chilot Y, Fekadu A, Woldeyesus S (Eds.), Barley based farming system in the high lands of Ethiopia. Ethiopian Agricultural Research Organization. Addis Ababa, Ethiopia pp. 67-89.

Bellon MR, Taylor JE (1993). Farmer soil taxonomy and technology adoption. Economic Development and Cultural Change 41:764-786.

Eticha F, Berghofer E, Grausgruber H (2008). Utilization of barley (*Hordeum vulgare* L.) landraces in the highlands of West Shewa, Ethiopia. Plant Genetic Resources: Characterization and Utilization 7(2):154-162.

FAO (1996). Global plan of action on the conservation and sustainable utilization of plant genetic resources for food and agriculture. The International Technical Conference on Plant Genetic Resources, Leipzig, Germany P 63.

Girma M (2014). Genetic erosion of barley in North Shewa Zone of Oromiya Region, Ethiopia. International Journal of Biodiversity and Conservation 6(3):280-289.

Guarino L (1995). Secondary sources on cultures and indigenous knowledge systems. In. Guarino L, Rao VR, Reid R (Eds.), Collecting Plant Genetic Diversity Technical Guidelines. CAB International, Wallingford, UK. pp. 195-228.

Hammer K, Kn puffer H, Xhuveli L, Perrino P (1996). Estimating genetic erosion in FV's – two case studies. Genetic Resources and Crop Evolution 43:329-336.

Magurran AE (1988). Ecological diversity and its measurements. Princeton, NJ, USA: Princeton University Press P 192.

Orabi J, Backes G, Wolday A, Yahyaoui A, Jahour A (2007). The Horn of Africa as a centre of barley diversification and a potential domestication site. Theoretical and Applied Genetics 14:1117-1127.

Shewayrga H, Sopade PA (2011). Ethnobotany, diverse food uses, claimed health benefits and implications on conservation of barley landraces in north eastern Ethiopia highlands. Journal of Ethno biology and Ethno medicine 7(19):1-15.

Teshome A, Baum BR, Fahrig L, Torrance JK, Arnason JT, Lambert JD (1997). Sorghum [*Sorghum bicolor* (L.) Moench] landrace variation and classification in North Shewa and South Welo, Ethiopia. Euphytica 97:255-263.