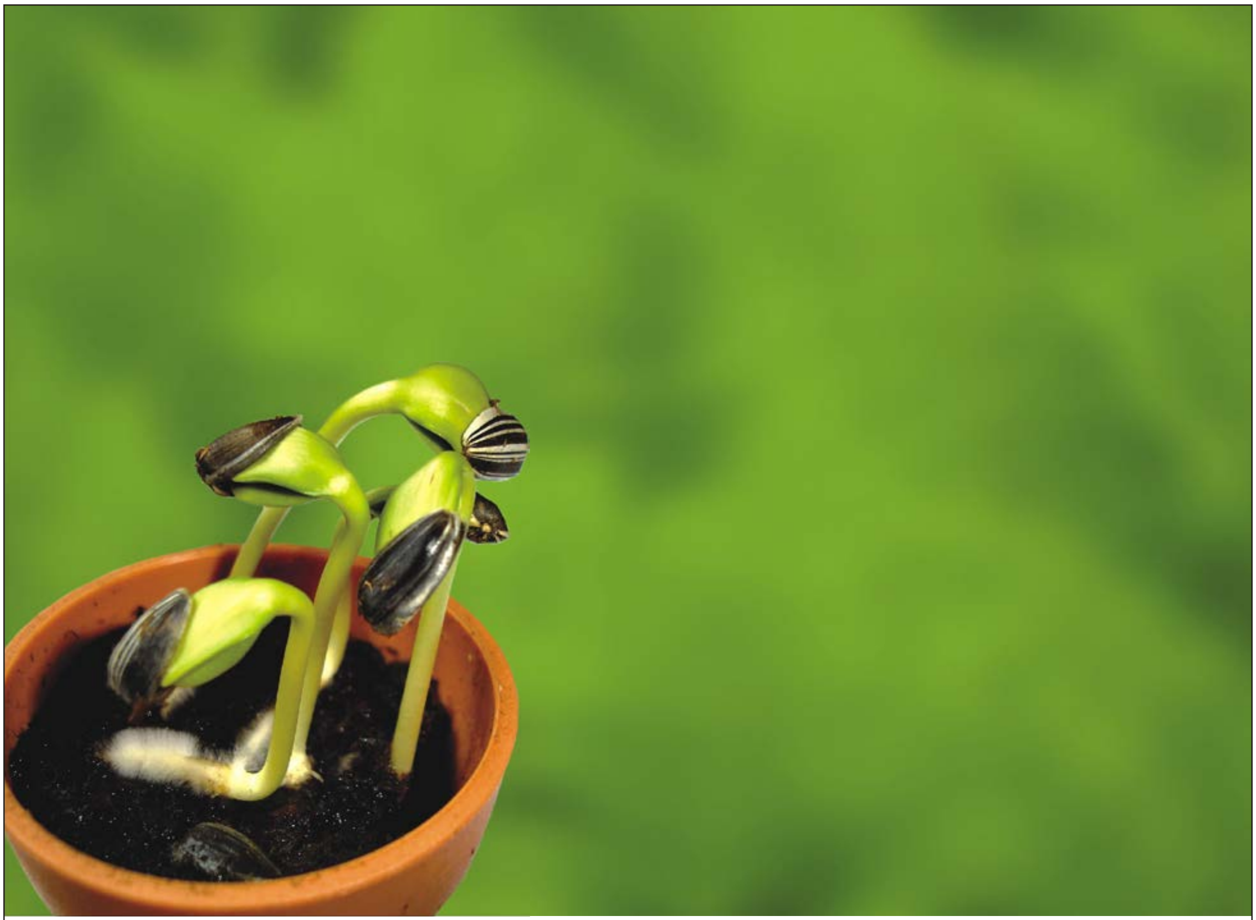

International Journal of

Plant Breeding and Genetics

ISSN 1819-3595

Academic Journals Inc.

www.academicjournals.com

International Journal of Plant Breeding and Genetics 9 (2): 68-76, 2015
ISSN 1819-3595 / DOI: 10.3923/ijpbg.2015.68.76

Variability, Heritability and Genetic Advance for Some Yield and Yield Related Traits in Barley (*Hordeum vulgare* L.) Landraces in Ethiopia

[1]F. Addisu and [2]T. Shumet
[1]Biodiversity Research Center, Arba Minch University, P.O. Box 21, Arba Minch, Ethiopia
[2]Department of Biology, College of Natural Sciences, Arba Minch University, P.O. Box 21, Arba Minch, Ethiopia

Corresponding Author: F. Addisu, Biodiversity Researcher Center, Arba Minch University, P.O. Box 21, Arba Minch, Ethiopia

ABSTRACT
Genetic diversity is essential for genetic improvement of a given crops. If the information on genetic diversity is not enough to utilize, the available genetic diversity study should be crucial. The objective of this study was to estimate the variability, heritability and genetic advance of barley landraces collection from Gamo highlands of Ethiopia. Accordingly, thirty six barley landraces were evaluated at Chencha, Southern Ethiopia in 2014/2015 cropping season to obtain information on genetic variability, heritability and genetic advance for grain yield and 12 yield related characters in Ethiopian barley landraces. The plot design used for the experiment was a randomized complete block design with three replications. The analysis of variance for the 36 barley landraces revealed significant difference among the landraces for the 13 quantitative characters studied, except spike length. The phenotypic coefficients of variability were higher than genotypic coefficients of variability for all of the characters indicating each and every characters were influenced by environmental factors up to some extent. The greater difference between GCV and PCV was observed spike and peduncle length indicating that these characters were influenced by environmental factors to greater extent. Heritability coupled with high genetic advance was observed for characters biomass per plant, grain yield and number of tiller per plant indicating that selection for these characters could be more effective due to additive gene action. Thus, this study revealed the presence of sufficient variability among the barley landraces in the country that can be exploited for germplasm enhancement.

Key words: Genetic diversity, phenotypic variation, genotypic variation, germplasm

INTRODUCTION
Barley (*Hordeum vulgare* L.) is one of the world's most ancient food crops. It has been an important cereal crop since the early stages of agricultural innovations 8,000-10,000 years ago (Giles and von Bothmer, 1985). It is an economically important cereal crop, ranking fourth after wheat, rice and maize in the world, both in terms of quantity produced and in area of cultivation (FAO., 2009).

Barley is an important crop in Ethiopian cereal production and in food security (Bekele *et al.*, 2005). Ethiopia is recognized as a major Vavilovian gene center. It is cultivated in a wide range of environments, from high altitude areas (>3000 masl) to low-rainfall environments, including the Rift Valley. A long history of cultivation, together with wide agro-ecological and cultural diversity in the country, has resulted in a large number of landraces of the crop which can adapt to different environmental conditions. Among the important traits that could exist in the landraces are earliness, high nutritional quality, disease and pest tolerance, tolerance to drought and other forms of abiotic stress and characters useful for low input agriculture (Yaynu, 2011).

Barley landraces represent over 90% of the barley cultivated in Ethiopia due to multiple food uses and adaptations to marginal environments (Hadado *et al*., 2009). In contrast to the genetic uniformity of modern cultivars, landraces exhibited variation both between and within populations. This within populations diversity of these barley landraces might allow them to cope with environmental stresses which is very important for achieving yield stability (Zhu *et al*., 2000).

Therefore, knowledge of the population structure of Ethiopian landraces together with a deeper understanding of the nature and extent of their variations, is an important prerequisite for the efficient conservation and use of the existing plant materials. Although, there is ample information on morphological variability of Ethiopian barley landraces, many studies concentrated on random samples and failed to assess variability of landraces within specific localities in terms of economically important traits that pave the way for further evaluation and utilization (Lakew *et al*., 1997).

Hence, this study was conducted with the objective to assess the variability, heritability and genetic advance of grain yield based on morphological traits of barley landraces collection from Gamo highlands of Ethiopia and select potential genotypes for a variety improvement program.

MATERIALS AND METHODS

Study area: The study was conducted in Southern Nations, Nationalities and People's Regional State, Gamo Gofa Zone, Chencha Woreda. Chencha is one of the districts in the highlands of Gamo Gofa Zone having two agro-ecological zones, Dega and Woina Dega, accounting for about 82 and 18% the total area, respectively. Altitude of the woreda varies from 1800-3500 masl. The area has bimodal rainfall. The first is from March to April and the second from June to October helping to grow meher (long rainy season) and belg (short rainy season), respectively. The annual rainfall ranges between 1201-1600 mm. The site is selected based on its barley crop production potential, along rainy season which covers from June to October.

Experimental materials and design

Field experimental setup: Thirty-six barley accessions were collected from three barley growing woreda's Chencha, Dita and Boke, in meher growing season, from October to December 2013 which covers an altitudinal range from 2,000-3,000 masl (Table 1). The accessions were collected from farmers' fields, by use of random sampling technique (Hawkes, 1976).

The Landraces were sown in the first week of June 2014 in Chencha Woreda experimental field in a randomized complete block design with three replications. The experimental plots consisted of 6 rows of 2.5 m length with 30 cm spaces and they were sown by hand. The plant density of 300 plants per m^2 and recommended dose of fertilizer (100:70:50, NPK) kg per ha were applied.

Table 1: List of barley landraces used in the experiment and their collection site

No.	Local name	Collection site	Altitude (masl)	No.	Local name	Collection site	Altitude (masl)
1	Duhe I	Chencha	2983	19	Solga II	Dita	2764
2	Locha I	Chencha	2992	20	Morka	Dita	2771
3	Maleno I	Chencha	2986	21	Chega IV	Dita	2867
4	Locha II	Chencha	2984	22	Osaha	Dita	2870
5	Chega I	Chencha	2968	23	NK 1	Dita	2871
6	Chentic	Chencha	2971	24	Maleno III	Dita	2888
7	Wolate	Chencha	2932	25	Locha II	Dita	2948
8	Kawbanga I	Chencha	2931	26	Losha	Dita	2950
9	Bote I	Chencha	2939	27	Bote II	Dita	2950
10	Maleno II	Chencha	2872	28	Kaobanga II	Dita	2904
11	Bote 2	Chencha	2886	29	Chega V	Dita	2762
12	Ye gibirina	Chencha	2885	30	Murka	Bonke	2384
13	Karsa Ocho	Chencha	2895	31	Shilash	Bonke	2365
14	Giso	Chencha	2810	32	Geze Banga	Bonke	2559
15	Bote 3	Chencha	2809	33	Wolkiie	Bonke	2557
16	Chega II	Dita	2536	34	Lealo	Bonke	2372
17	Solga I	Dita	2542	35	Mirichicho	Bonke	2379
18	Chega III	Dita	2636	36	NK II	Bonke	2354

Table 2: Physico chemical characteristic of the soil during the study period, Chencha (2014)

Soil type	Soil texture (%)			Absorbent phosphorus (ppm)	Total nitrogen (%)	Organic carbon (%)	Total acidity (pH)	Electrical conductivity (dS mG^1)	Soil salinity (dS mG^1)	Soil salinity (ppm)
	Sand	Silt	Clay							
Clay	5	3	92	14.6	803.9	220.5	6.8	0.2	1.3	832

Weeds were removed by hand prior to flowering stage. To determine the physico-chemical characteristics of the soil, soil samples were taken from the depths of 0-30 and 30-60 cm and it was analyzed at Arba Minch University soil and water quality laboratories (Table 2).

Agronomic data collected: Data was recorded for thirteen quantitative characters using barley Descriptors (IPGRI, 1994).

- **Days to Heading (DH):** The number of days from planting up to 50% heading
- **Days to Maturity (DM):** The number of days from planting up to physiological maturity
- **Thousand Seed weight (TSW):** Weight of 1000 seeds randomly taken from each plot and weighed in gram
- **Grain filling period (GFP):** It was determined by subtracting days to heading from days to maturity
- **Plant height (PH):** It was recorded at maturity from ground level to the tip of the spike of the main tillers excluding awns (cm)
- **Spike Length (SL):** Distance from the base of the spike to the tip of the highest spikelet (excluding own) in cm
- **Number of grains per spike (NSS):** The actual count of the number of spikelet of the mother spike

- **Biomass per plant (BPP):** Biomass of the harvested plant was weighed at maturity and average was taken in gram
- **Number of Spikelet's per spike(NSPS):** Twenty spikes of the main tillers and average was taken
- **Harvest index (HI) (%):** It was calculated by the equation:

$$\text{Harvest index} = \frac{\text{Grain yield per plant}}{\text{Biomass per plant}} \times 100$$

- **Number of tillers per plant:** The ear bearing tillers (spikes) was counted
- **Peduncle length (PL):** It was measured from the upper most node to the base of spikes
- **Grain Yield (GY):** The total grain obtained from each plant was weighed in gram and analyzed

Data analysis: The observations were recorded for the thirteen quantitative characters. The mean performance of individual landrace was recorded and employed for statistical analysis (Table 1). Analysis of variance to test the significance for each character was carried out as per methodology advocated by Gomez and Gomez (1984), at a probability level of 5%.

Phenotypic Coefficient of Variability (PCV) and Genotypic Coefficient of Variability (GCV) and heritability in broad sense (h^2) were calculated by the formula given by Burton and Devane (1953) and genetic advance that is the expected genetic gain was calculated by using the procedure given by Johnson *et al*. (1955).

RESULTS AND DISCUSSION

Mean and range: For thirteen quantitative character evaluated, the descriptive statistics including the extreme landrace mean and their standard errors values were obtained on the basis of average data (Table 3 and 4). In general, barley landraces showed wide range of variability for most of the characters and all the traits exhibited broad spectrum of ranges between the maximum and minimum mean values. For instance, number of spikelet per spike ranged from 18-80 with a mean of 50.48, plant height ranging from 63.9-121 cm with a mean of 88.68 cm. Similarly, biomass per plant and number of grains per spike ranged from 24.08-65.21 g and 21-59, respectively while spike length varied from 4.3-12.9 cm with a mean length of 8.78 cm, number of tillers per plant ranged from 3-17 with a mean of 7.67 tiller per plant (Table 4). Alemayehu and Parlevliet (1997) studied variation of six quantitative characters in 18 Ethiopian barley landraces and reported similar results.

Grain yield per plant was varied from 4.3-21.9 g the mean grain yield per plant was 9.44 g. The maximum grain yield was 21.9, from Murka, followed by Kawbanga I, Maleno III, Bote 3 and Chentic with a yield 15.3, 13.5, 13 and 12.8 g, respectively. While low yield were obtained for Solga II, Lealo, Mirichicho and Duhe I, 4.9, 5.1, 5.5 and 5.6 g per plant, respectively (Table 3). Thus, it is possible to succeed in improving grain yield by direct selection. Asfaw and von Bothmer (1990) and Kebebew *et al.* (2001) reported similar phenotypic diversity in Ethiopia barley landraces.

Analysis of variance components: The results of the analysis of variance for the 13 quantitative characters presented in Table 5 reveal that the 36 barley landraces differed

Table 3: Mean performance of 13 quantitative characters of the 36 barley landraces

Varieties	DH	GFP	MD	NTPP	HI	PL	PH	SL	NSPS	NGPS	BPP	TSW	GY
Duhe I	72.40	51.7	124.1	5.7	23.2	28.4	86.5	8.50	29.0	30.4	24.1	36.8	5.6
Locha I	71.10	51.1	122.2	5.3	17.2	28.8	119.9	9.80	51.3	21.8	41.8	55.1	7.2
Maleno I	72.30	57.5	129.8	8.5	19.0	18.0	108.3	9.60	54.0	23.5	45.4	56.3	8.6
Locha II	75.00	61.5	137.2	5.4	18.3	20.0	93.0	10.00	45.7	23.7	64.9	61.0	11.9
Chega I	79.70	54.6	134.3	10.6	39.4	23.3	100.1	9.20	42.0	58.0	55.6	48.0	11.6
Chentic	75.20	53.7	128.9	6.3	24.7	23.8	87.9	9.50	36.0	42.6	51.6	42.8	12.8
Wolate	73.70	52.1	125.8	7.1	22.2	17.1	82.4	10.00	42.0	35.1	40.0	38.7	8.9
Kawbanga I	78.81	50.5	129.3	5.0	31.6	19.2	82.2	7.90	58.0	44.4	48.5	49.2	15.3
Bote I	73.30	52.5	125.8	16.4	20.0	19.7	91.2	8.60	61.0	35.4	44.5	38.7	8.9
Maleno II	69.60	61.6	131.2	15.4	18.8	21.5	88.5	8.60	32.0	24.6	45.7	49.8	8.6
Bote 2	78.01	61.0	139.0	6.3	28.0	19.0	87.8	8.20	42.3	36.0	39.3	48.1	11.0
Ye gibirina	75.20	54.5	129.7	5.4	28.2	21.3	81.1	6.30	54.0	38.6	38.5	46.8	10.9
Karsa Ocho	85.10	56.5	141.6	7.6	24.2	17.4	86.5	9.10	46.0	26.9	41.5	57.3	10.0
Giso	76.82	53.1	129.9	7.2	20.5	19.6	87.0	8.20	35.0	29.0	46.0	46.2	9.4
Bote 3	79.70	49.6	129.3	13.1	25.7	15.8	91.0	8.79	63.0	35.8	50.4	50.4	13.0
Chega II	72.40	56.3	128.7	6.2	22.5	19.4	86.5	7.20	62.0	32.0	41.1	44.0	9.2
Solga I	77.56	65.9	143.4	4.2	20.4	22.5	86.0	8.35	54.0	25.3	62.3	62.0	12.7
Chega III	73.80	65.3	139.1	4.2	19.4	16.7	86.5	7.20	78.0	28.0	45.4	45.0	8.8
Solga II	80.67	67.7	148.4	4.1	15.5	15.6	68.9	7.80	46.7	21.7	31.6	41.0	4.9
Morka	78.00	53.3	131.3	5.5	16.0	21.0	76.46	8.28	64.0	23.0	35.6	42.0	5.7
Chega IV	75.90	55.5	131.4	4.4	26.1	16.4	83.3	9.80	75.0	36.0	25.7	37.2	6.7
Osaha	74.70	72.9	147.6	5.5	20.0	21.4	98.6	8.70	24.0	23.5	28.9	46.0	5.8
NK 1	92.00	58.5	150.5	6.2	22.9	20.5	66.8	7.80	55.0	25.2	47.6	59.0	10.9
Maleno III	74.85	61.1	135.9	5.8	30.3	24.9	106.8	9.05	64.0	41.0	44.6	50.0	13.5
Locha II	79.60	60.2	139.8	6.7	18.6	15.1	80.63	8.98	47.0	24.0	64.8	60.3	12.0
Losha	80.70	62.4	143.1	7.0	23.5	16.6	91.5	8.66	48.3	31.0	47.0	50.0	11.0
Bote II	80.44	53.7	134.1	9.5	22.2	17.6	89.9	9.45	32.0	34.0	30.5	37.0	6.8
Kaobanga II	65.00	73.0	138.0	6.7	24.9	21.2	82.1	7.80	41.0	30.0	38.8	50.0	9.6
Chega V	83.00	60.0	143.0	10.0	26.9	16.4	83.4	7.37	78.0	38.9	34.4	43.2	9.2
Murka	87.50	65.4	152.9	5.6	27.3	17.5	85.2	8.60	43.0	36.2	42.4	49.1	21.9
Shilash	88.77	61.5	150.2	6.0	17.6	15.6	85.4	9.89	63.0	24.8	38.1	44.9	6.7
Geze Banga	74.11	54.9	129.0	10.9	17.6	19.0	91.8	9.70	49.0	24.8	37.0	43.8	6.5
Wolkiie	83.10	67.9	151.0	5.3	21.6	21.5	87.3	9.00	46.0	27.2	36.0	50.4	7.8
Lealo	87.57	48.2	135.8	12.4	18.4	17.2	87.7	9.50	38.3	23.3	27.4	36.7	5.1
Mirichicho	76.80	57.7	134.5	13.1	16.3	17.9	80.9	10.40	65.0	24.1	33.8	41.1	5.5
NK II	86.10	50.7	136.8	11.1	21.0	26.4	86.5	10.00	57.3	34.2	30.0	35.5	6.3

DF: Days to heading (days), GFP: Grain filling period (days), DM: Days to maturity (days), NTPP: Number of tiller per plant, HI: Harvest index, PL: Peduncle length (cm), PH: Plant height (cm), SL: Spike length(cm), NSPS: Number of spikelet's per spike, NGPS: Number of grains per spike. BPP: Biomass per plant (g), TSW: Thousand seed weight (g), GY: Grain yield per plant (g)

significantly ($p<0.05$) in all of the characters considered, except spike length, indicating the presence of notable morphological variability among them which can be exploited through selection. Similar work was also reported by Jalata *et al*. (2011). Ethiopian barley landraces diversity was very high due to ecological heterogeneity. It is established that genetic variability is a basic pre requisite for plant breeding programme on which selection acts to evolve superior genotype. Thus

Table 4: Ranges, means and standard errors of means for 13 quantitative traits of 13 quantitative traits of 36 barley landraces

Characters	Mean	Standard deviation	Minimum	Maximum	Variance	Standard error of means
DH	77.83	6.350	63.00	98.00	40.39	0.610
GFP	58.27	6.690	47.00	75.00	44.73	0.640
MD	136.05	8.370	121.00	154.00	70.06	0.850
NTPP	7.67	3.540	3.00	17.00	12.52	0.340
HI	22.47	5.450	13.79	40.90	29.76	0.520
PL	20.01	4.820	14.00	33.60	23.25	0.460
PH	88.68	11.200	63.90	121.00	125.46	1.080
SL	8.78	1.940	4.30	12.90	3.79	0.187
NSPS	50.48	14.760	18.00	80.00	217.80	1.420
NGPS	30.99	8.144	21.00	59.00	66.33	0.787
BPP	41.69	10.061	24.08	65.21	101.23	0.970
TSW	47.04	7.510	33.70	64.00	56.43	0.720
GY	9.44	3.510	4.30	21.90	12.37	0.340

DF: Days to heading (days), GFP: Grain filling period (days), DM: Days to maturity (days), NTPP: Number of tiller per plant, HI: Harvest index, PL: Peduncle length (cm), PH: Plant height (cm), SL: Spike length (cm), NSPS: Number of spikelet's per spike, NGPS: Number of grains per spike, BPP: Biomass per plant (g), TSW: Thousand seed weight (g) GY: Grain yield per plant (g)

Table 5: Mean squares from analysis of variance for the 13 characters of the 36 barley landraces

Source of variation	df	Mean square												
		DH	GFP	MD	NTPP	HI	PL	PH	SL	NSPS	NGPS	BPP	TSW	GY
Genotype	35	109.84*	128.24*	205.45*	31.260**	76.68*	41.20*	374.830*	5.75^{ns}	546.20*	188.40*	309.380*	163.90*	35.360*
Replication	2	10.57	17.36	18.06	15.440	10.87	33.44	19.530	18.77	360.34	6.59	0.309	21.25	2.325
Error	70	6.52	3.76	3.86	3.073	6.83	13.98	3.810	3.80	49.50	6.15	0.033	3.70	1.167

*Significant at 0.05, ns: Non significant at 0.05

the higher the amount of variation present for the various characters in the chosen materials, greater is the scope for its improvement through selection.

The Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) were computed to access the existing variability in the characters. The PCV were higher than GCV for all the characters indicating each and every characters were influenced by environmental factors up to some extent (Table 6).

High phenotypic coefficients of variation was observed for number of tiller per plant (46.1%), grain yield (37.6%), number of spikelets per spike (29.1%) and number of grain per spike (26.4%). Greater genotypic coefficients of variation were also observed for characters, number of tiller per plant (40%), grain yield (35.8%), number of spikelets per spike (25.5%) and number of grain per spike (25.2%) (Table 6). This observation is in agreement with the result of Andonov *et al*. (1979). The greater difference between GCV and PCV were observed in spike and peduncle length indicating that these characters were influenced by environmental factors to greater extent. Very small difference between GCV and PCV was observed biomass per plant, plant height, maturity days, grain filling period and thousand seed weight, indicated that there was very little environmental influence on these characters; the characters cannot be improved by providing favorable environment. In line with this, Jalata *et al*. (2011), reported the same result for grain yield, biomass yield per plant across three different locations.

Table 6: Estimates of phenotypic (F^2p), genotypic (F^2g) variance, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability in broad sense (h^2), genetic advance (GA) and GA as percentage of mean (GAM) of 13 quantitative traits of 36 barley landraces

Character	F^2p	F^2g	PCV (%)	GCV (%)	h^2 (%)	GA	GAM
DH	41.0	34.44	8.2	7.5	84.0	11.07	14.22
GFP	45.3	41.49	11.6	11.1	91.6	12.70	21.80
MD	71.1	67.20	6.2	6.0	94.5	16.41	12.06
NTPP	12.5	9.40	46.1	40.0	75.2	5.48	71.45
HI	30.1	23.28	24.4	21.5	77.3	8.73	38.85
PL	23.1	9.07	24.0	15.1	39.3	3.89	19.44
PH	127.5	123.67	12.7	12.5	97.0	22.56	25.44
SL	4.6	0.65	24.4	9.2	14.1	0.62	7.06
NSPS	215.1	165.57	29.1	25.5	77.0	23.32	46.20
NGPS	66.9	60.75	26.4	25.2	90.8	15.34	49.50
BPP	103.2	103.12	24.4	24.44	99.9	20.99	50.35
TSW	57.1	53.40	16.1	15.5	93.5	14.56	30.95
GY	12.6	11.40	37.6	35.8	90.5	6.62	70.13

DF: Days to heading (days), GFP: Grain filling period (days), DM: Days to maturity (days), NTPP: Number of tiller per plant, HI: Harvest index, PL: Peduncle length (cm), PH: Plant height (cm), SL: Spike length (cm), NSPS: Number of spikelet's per spike, NGPS: Number of grains per spike, BPP: Biomass per plant (g), TSW: Thousand seed weight (g), GY: Grain yield per plant (g)

Heritability estimate is very important to a breeder since it indicates the possibility and extent to which improvement is possible through selection. It is also a measure of genetic relationship between parents and their offspring (Robinson *et al*., 1956). High heritability alone is not enough to make efficient selection in the advanced generations and unless accompanied by substantial amount of genetic advance. Burton (1952) pointed out that heritability in combination with intensity of selection and amount of variability present in the population influences the genes to be obtained from the selection. Thus genetic advance is another important selection parameter.

In this study the heritability estimates in broad sense were classified into 3 groups such as high (>90%), moderate (75-60%) and low (<59%). The high heritability in broad sense were observed for the characters viz. biomass per plant (g), plant height (cm), maturity date, thousand seed weight (g), grain filling period, number of grain per spike and grain yield (g). The moderate heritability in broad sense was observed for harvest index, number of spike per spikelet and number of tiller per plant. Similar results have been reported by Aidun *et al*. (1990).

Genetic advance in percentage of mean give more precise result in comparison to only genetic advance. High genetic advance in percentage of mean coupled with high heritability was recorded for the characters biomass per plant, grain yield and number of tiller per plant indicating that selection for these characters could be more effective due to additive gene action. Panse (1957) viewed that if a character is governed by non-additive gene action it may give high heritability but low genetic advance, whereas, if it is governed by additive gene action heritability and genetic advance would be high. Higher estimates of heritability along with high genetic advance provide good scope for further improvement in advance generation if these characters are subjected to mass progeny and clonal selection.

CONCLUSION

Thirty six barley landraces were evaluated in randomized block design for 13 quantitative traits to elucidate information on the nature and magnitude of genetic variability and the degree of genetic divergence.

The result showed that genetic variability amongst the tested landraces and this is important in selection of parent for hybridization. Since crop improvement depends upon magnitude of genetic variability in base population. Therefore, an understanding of the gene action associated with the expression of yield related traits will facilitate the exploitation of the component approach in the improvement of barley. Thus, the various analysis carried out had shown wide variability among the 36 barley landraces for the 13 traits, the extent of heritability (broad sense) of the traits and the different forms of association existing among different traits. The wide range of variability observed for the characters evaluated may be attributed to diverse genetic background of the landraces and these could be used for selection of the genotypes for crosses.

Heritability estimates along with genetic advance is more helpful in foresee the genetic gain under selection than heritability estimates alone. High genetic advance joined with heritability was observed for biomass per plant, grain yield and number of tiller per plant. Therefore selection of genotypes based on these indicated traits will be effective. The study revealed the presence of sufficient genetic variability among the landraces in the country that can be exploited for germplasm enhancement.

ACKNOWLEDGMENTS

The authors would like to thank Arba Minch University for financing this research project and also Dr.Alemayehu H/micheal and Dr.Tesema Tanto, for their technical support and providing the land.

REFERENCES

Aidun, V.L., B.L. Harvey and B.G. Rossnagel, 1990. Heritability and genetic advance of hull peeling in two-row barley. Can. J. Plant Sci., 70: 481-485.

Alemayehu, F. and J.E. Parlevliet, 1997. Variation between and within Ethiopian barley landraces. Euphytica, 94: 183-189.

Andonov, K.L., B.S. Sariev and L.P. Zhundibaev, 1979. Structure of phenotypic variability in traits of spring barley. Acta Agric. Shanghai, 22: 187-188.

Asfaw, Z. and R. von Bothmer, 1990. Hybridization between landrace varieties of Ethiopian barley (*Hordeum vulgare* ssp. Vulgare) and the progenitor of barley (*H. vulgare* ssp. spontaneum). Hereditas, 112: 57-64.

Bekele, B., A. Fekadu and L. Berhane, 2005. Food Barley in Ethiopia. In: Food Barley: Importance, Uses and Local Knowledge, Grando, S. and H.G. Macpherson (Eds.). International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, ISBN-13: 9789291271733, pp: 53-83.

Burton, G.W., 1952. Quantitative inheritance in grasses. Proceedings of the 6th International Grassland Congress, August 17-23, 1952, Pennsylvania State College, USA., pp: 277-283.

Burton, W.G. and E.H. Devane, 1953. Estimating heritability in tall fescue (*Festuca Arundinacea*) from replicated clonal material. Agron. J., 45: 478-481.

FAO., 2009. The State of Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy.

Giles, B.E. and R. von Bothmer, 1985. The progenitor of barley (*Hordeum vulgare* spp. spontaneum)-its importance as a gene resource. Sveriges Utsaedesfoerenings Tidskrift, 95: 53-61.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Sons Inc., New York, USA., ISBN: 13-9780471879312, pp: 13-175.

Hadado, T.T., D. Rau, E. Bitocchi and R. Papa, 2009. Genetic diversity of barley (*Hordeum vulgare* L.) landraces from the central highlands of Ethiopia: comparison between the *Belg* and *Meher* growing seasons using morphological traits. Genet. Resour. Crop Evol., 56: 1131-1148.

Hawkes, J.G., 1976. Sampling Gene Pools. In: Conservation of Threatened Plants, Simmons, J.B., R.I. Beyer, P.E. Brandham, G.L. Lucas and V.T.H. Parry (Eds.). Springer, New York, USA., ISBN-13: 978-1-4684-2517-8, pp: 145-154.

IPGRI., 1994. Description of barley (*Hordeum vulgare* L.). International Plant Genetic Resources Institute (IPGRI), Rome, Italy.

Jalata, Z., A. Ayana and H. Zeleke, 2011. Variability, heritability and genetic advance for some yield and yield related traits in Ethiopian barley (*Hordeum vulgare* L.) landraces and crosses. Int. J. Plant Breed. Genet., 5: 44-52.

Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in soybeans. Agron. J., 47: 314-318.

Kebebew, F., Y. Tsehaye and T. McNeilly, 2001. Morphological and farmers cognitive diversity of barley (*Hordeum vulgare* L. [Poaceae]) at Bale and North Shewa of Ethiopia. Genet. Res. Crop Evol., 48: 467-481.

Lakew, B., Y. Semeane, F. Alemayehu, H. Gebre, S. Grando, J.A.G. van Leur and S. Ceccarelli, 1997. Exploiting the diversity of barley landraces in Ethiopia. Genet. Resour. Crop Evol., 44: 109-116.

Panse, V.G., 1957. Genetics of quantitative characters in relation to plant breeding. Indian J. Genet., 17: 318-328.

Robinson, H.F., G.H. Hamson and R.E. Comstock, 1956. Biometrical studies of yield in segregating populations of Korean Lespedeza. Agro. J., 40: 260-672.

Yaynu, H., 2011. Response of Barley Landraces to Low-Moisture Stress in a Low-Rainfall Environment. In: Barley Research and Development in Ethiopia, Mulatu, B. and S. Grando (Eds.). International Center for Agricultural Research in the Dry Areas, Holeta, Ethiopia, pp: 47-56.

Zhu, Y., H. Chen, J. Fan, Y. Wang and Y. Li *et al*., 2000. Genetic diversity and disease control in rice. Nature, 406: 718-722.