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Diversity and Agronomic Potential of Barley (*Hordeum vulgare* L.) Landraces in Variable Production System, Ethiopia

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Abstract: Knowledge on the genetic diversity and agronomic potential of barley landraces in variable environments is an important task to design strategic utilization, targeted collections and introductions of germplasms. Study on Ethiopian barley landraces revealed that the variability among the tested 181 barley landraces is high enough to exercise selection for high yielding and early maturing landraces suitable for areas with variable rainfall. Hierarchal cluster analysis resulted in ten distinct clusters with maximum intercluster distances, low intracluster distances and coefficient of variation. The result disclosed the positive contribution of early heading, longer grain filling period, medium plant height and thousand-grain weight to grain yield in belg barley production system in Ethiopia, indicating the potential role landraces can play in stabilizing food security variable rainfall conditions.

Key words: Barley · Landraces · Diversity · Intercluster · Euclidean distance and cluster

INTRODUCTION

Barley is an important food crop in the highland parts of Ethiopia. It is the crop matures early and an emergency crop bridging the critical food shortage occurs in September. Barley genetic resources are the building block of breeding programs, form the raw materials from which new varieties have been systematically breed to meet the ever-growing demand for more food. Ethiopia is the centre of diversity for barley (*Hordeum vulgare*) with many landraces available [1]. Diverse barley landraces are adapted to different barley growing agro-ecologies of Ethiopia [2]. Ethiopian barley landraces have useful traits, especially for resistance to diseases, such as powdery mildew barley yellow dwarf virus, net blotch, scald and loose smut [3]. Other useful characteristics of Ethiopian barley include high tillering capacity; tolerance to marginal soil conditions, barley shoot fly, aphids and frost; vigorous seedling establishment; and quick grain filling period [4]. Despite the immense variability and agronomic potential the Ethiopian barley landraces have, huge number of introductions have been made for the variety yield trials in Ethiopia. However, most introduced lines either were highly susceptible to scald, leaf blotch and perform poorly in a variable environments [4]. Barley production in Ethiopia is thus based on populations, a mixture of landraces differ in productivity, phenotypic plasticity, seed colour, maturity, height, disease reaction and other traits. Thus it was important to study the potential of the available barley landraces and document information enabling barley researchers to design strategic germplasm enrichment and improvement programs aimed at stable barley production.

MATERIALS AND METHODS

One hundred eighty one (181) barley landraces representing Shewa and Wollo collections, received from the Ethiopian Institute of Biodiversity conservation were evaluated between 1995-2004 at two locations (Ankober and Kotu) located North east of Addis Ababa at an elevation of 2800-3000 meter above sea level. The study areas are characterized by cool climate, short and unpredictable rainfall from February to May, locally and hereafter named *belg* production system. Five blocks of non-replicated augmented design in which thirty-six

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landraces were assigned in each block and the local check, *Kesselie* was placed at the interval of five plots per block. Each plots ($1m^2$) was drilled at the seed rate of 85kg/ha of barley and fertilized by 50/100 kg/ha Urea/DAP. Data on days to heading (DH), days to maturity (DMT), grain filling period (GFP = DMT-DH), thousand-grain weigh (TSW) and grain yield (GY) were recorded on plot basis, whereas plant height (PHT) was recorded on randomly selected ten plants and averaged to make plot data value. Mean data of each traits were used for euclidean distance (D^2) analysis using SPSS16 statistical software. Dendrogram of 181 barley landrace was done using hierarchical analysis, between–groups linkage methods of SPSS16 statistical software. One-way analysis of variances between ten clusters and descriptive statistics of the traits were done using the same statistical software. Taking X = mean grainy yield of all landraces within a given cluster, Y= mean grain yield of Kesselie and the grain yield advantage of landraces in each cluster as compared (A) was estimated as.

RESULTS

Diversity of Barley Landraces: Hierarchal cluster analysis classified the tested barley landraces into ten significantly different clusters (Fig. 1 and Table 4). Cluster VI, V, X, III and IV contained the highest number of landraces, respectively, whereas the lowest number of landraces were included in clusters I, II and VII (Fig. 1 and Table 1 and). The popular local check barley cultivar, *Kesselie* was included in cluster VI. High intercluster euclidean distances (D^2) were noted between cluster I and VII; I and VIII; I and IV; I and VI; VII and IX; VII and IX while cluster V and X; VII and VIII; II and X had low intercluster distances (Table 1). Eighty-eight landraces were superior to *Kesselie* in most agronomically important traits considered, including grain yield. Agronomically superior barley landraces were included in clusters I, III, IX, II, X and V, hereafter named as a high yielding cluster group while cluster VI, IV, VIII and VII, named as low yielding cluster group were characterized by low mean grain yield and 1000-grain weight (Table 3). In all cases, the maximum intercluster distances were recorded between pair of clusters from high and low yielding cluster groups. Low intracluster distances presented in the diagonal of (Table1) and coefficients of variations for day to heading, maturity, grain filling period, plant height, grain yield and thousand-grain weight (Table 2) indicated that the variability among landraces within clusters is low. Taking the mean values of *Kesselie* as a reference, landraces in high yielding cluster groups gave an average grain yield, plant height and thousand-grain weight advantage of 49, 8 and 5%, respectively. In contrast, the average plant height, thousand-grain weight and grain yield of

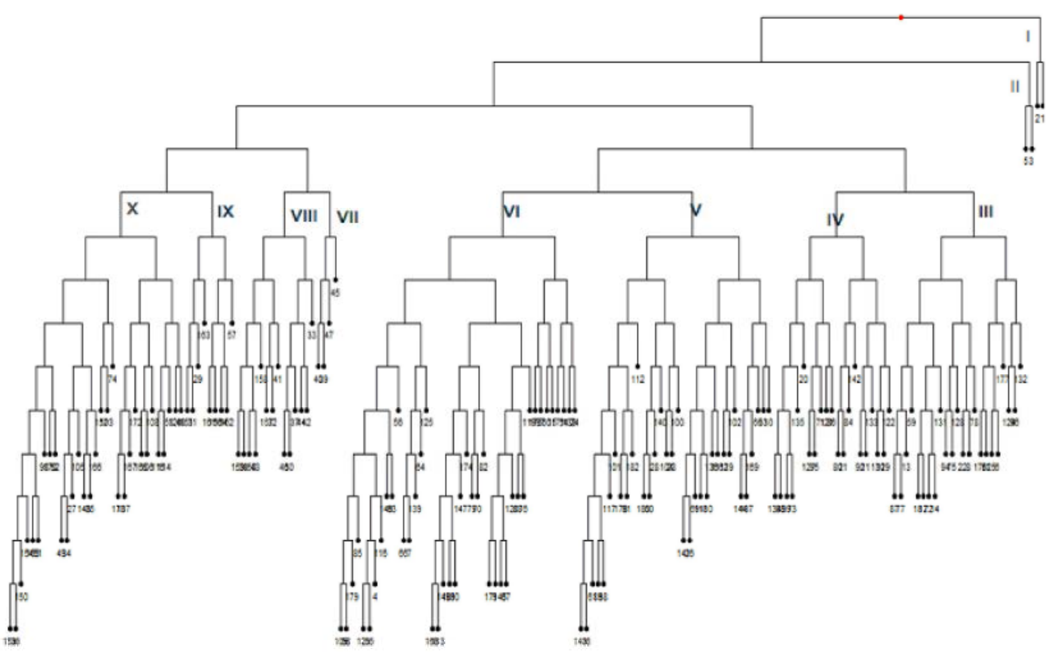

Fig. 1: Dendrogram of 181 food Ethiopian barley landrace using Hierarchical analysis, between –groups linkage methods [1]Roman numbers in the root indicating the cluster number

Table 1: Dissimilarity (intracluster along and intercluster above the diagonal) matrix using Euclidean distance (D^2) of 181 barley Ethiopian landraces

Cluster number	I	II	III	IV	V	VI	VII	VIII	IX	X
I	154.34	679.43	276.22	1582.27	1067.03	1353.67	1986.44	1809.46	474.61	894.89
II		194.78	403.39	902.89	387.63	674.27	1307.10	1130.10	204.90	215.47
III			107.10	1306.19	790.98	1077.60	1710.37	1533.39	198.61	618.83
IV				123.90	515.28	228.64	404.23	227.22	1107.77	687.43
V					89.41	286.65	919.49	742.49	592.51	172.17
VI						121.76	632.86	455.86	879.15	458.81
VII							36.54	177.02	1511.98	1091.65
VIII								291.32	1334.98	914.65
IX									257.2	420.35
X										125.1
Landrace per cluster	2	2	23	21	33	42	4	14	9	31

Table 2: Intraclusters descriptive statistics of for days to heading(DHE), Days to maturity (DMT), grain filling period (GFP), plant height (PHT), thousand-grain weight (TGW) and grain yield (GY kg/ha) of 181 barley landraces within each cluster, Ethiopia

cluster		DHE	DMT	GFP	PHT	TGW	GY
I	Mean	84.00	122.00	38.00	71.00	44.80	2634.00
	Standard deviation	1.98	2.11	2.18	2.98	2.89	54.90
	Coefficient of variation %	2.36	1.73	5.74	4.20	6.45	2.08
II	Mean	89.90	127.00	37.10	70.80	37.80	1898.00
	Standard deviation	4.06	3.19	3.91	8.15	2.88	46.20
	Coefficient of variation%	4.52	2.51	10.54	11.51	7.62	2.43
III	Mean	90.60	128.00	37.00	69.20	39.00	2242.00
	Standard deviation	3.13	3.13	5.29	5.63	2.59	72.90
	Coefficient of variation%	3.45	2.45	14.30	8.14	6.64	3.25
IV	Mean	95.50	129.00	33.50	60.80	36.10	1051.00
	Standard deviation	4.96	2.26	3.71	7.78	2.43	64.40
	Coefficient of variation%	5.19	1.75	11.07	12.80	6.73	6.13
V	Mean	90.10	127.00	37.30	69.00	37.90	1567.00
	Standard deviation	4.13	3.26	3.45	6.94	2.66	58.20
	Coefficient of variation%	4.58	2.57	9.25	10.06	7.02	3.71
VI	Mean	92.80	129.00	35.90	66.20	37.10	1280.00
	Standard deviation	4.05	2.12	3.72	7.69	2.30	70.80
	Coefficient of variation%	4.36	1.64	10.36	11.62	6.20	5.53
VII	Mean	97.60	129.00	31.40	52.20	33.20	662.00
	Standard deviation	2.61	0.00	2.61	5.76	1.47	40.20
	Coefficient of variation%	2.67	0.00	8.31	11.03	4.43	6.07
VIII	Mean	97.20	129.00	32.00	56.30	33.90	883.00
	Standard deviation	2.48	0.58	2.63	4.21	4.47	63.30
	Coefficient of variation%	2.55	0.45	8.22	7.48	13.19	7.17
IX	Mean	87.80	127.00	38.90	75.50	40.10	2063.00
	Standard deviation	4.65	3.07	3.93	6.77	2.45	50.70
	Coefficient of variation%	5.30	2.42	10.10	8.97	6.11	2.46
X	Mean	90.50	128.00	37.50	71.70	38.90	1728.00
	Standard deviation	3.87	2.87	3.42	7.82	2.72	44.00
	Coefficient of variation%	4.28	2.24	9.12	10.91	6.99	2.55

Table 3: Mean cluster values of days to heading(DHE). Days to maturity (DMT), grain filling period (GFP), plant height (PHT), thousand-grain weight (TGW) and grain yield (GY kg/ha) of 181 barley landraces, Ethiopia

Clusters™	DF	DMT	GFP	PHT (cm)	TGW	GY (kg/ha)	A¥
I	84,00	122,00	38,00	71,00	44,80	2634,00	93,84
III	90,60	127,60	37,00	69,20	38,96	2241,80	64,98
IX	87,82	126,76	38,94	75,53	40,07	2062,71	51,80
II	89,87	127,00	37,13	70,78	37,83	1898,00	39,09
X	90,54	128,00	37,46	71,66	38,89	1728,31	27,19
V	90,15	127,41	37,26	69,02	37,86	1567,02	14,80
Kesselie	92,00	129,00	37,00	66,00	38,00	1358,82	0,00
VI	92,83	128,76	35,93	66,17	37,12	1280,41	-5,77
IV	95,46	128,92	33,46	60,85	36,09	1051,85	-22,59
VIII	97,17	129,17	32,00	56,33	33,93	833,33	-38,68
VII	97,60	129,00	31,40	52,20	33,20	662,40	-51,25

¥ = grain yield advantage of landraces in each cluster compared to the mean of the popular local check barley cultivar, Kesselie

™ = Clusters above and below Kesselie are considered as high and low yielding cluster groups respectively

Table 4: Analysis of variance for traits of ten clusters from181 barley landraces, Ethiopia

	Clusters					
	Mean Square	Degree of freedom	Mean Square	Degree of freedom	F	Sig.
Days to heading	142.674	9	16.306	171	8.750	0.000
Days to maturity	16.219	9	7.591	171	2.136	0.029
Grain filling period	74.674	9	13.021	171	5,735	0.000
Plant height	590.299	9	52.088	171	11,333	0,000
1000-seed weight	57.722	9	7.535	171	7.661	0.000
Grain yield kg/ha	3042106.619	9	3225.446	171	943.159	0.000

landraces in low yielding clusters were decreased by 10, 10, 8 and 29% (Table 3). Analysis of variance between clusters showed significant difference (P <5%) for days to heading, maturity, grain filling period, plant height, thousand-grain weight and grain yield (Table 4). Moreover, high yielding cluster groups were positively associated with early flowering, medium plant height, long grain filling period and thousand-grain weight and whereas the low yielding cluster groups counterparts contained landraces with characterized by late to heading, maturity and short plant height (Tables 2 and 3).

DISCUSSION

Hierarchical clustering analysis using euclidean distance of 181 landraces results in ten clusters, each clusters contains landraces with contrasting expression of agronomic traits. Based on the agronomic merit of each clusters, the ten clusters in turn re-classified into high and low yielding cluster groups (Table 3). The maximum intercluster distances between pair of clusters from high and low yielding cluster groups, indicating that barley landraces included in those clusters groups are variable for the traits considered. The result is supported by the earlier studies [1,2,5-7]. All intracluster distances are low, suggesting barley landraces in each clusters are relatively homogenous and selection within clusters may not be progressive. This has been confirmed by the lowest coefficients of variation for days to heading, maturity, grain-filling period, plant height, grain yield and thousand-grain weight within each clusters (Table 2). Thus selection and intercrossing of landraces within clusters is not responsive, whereas intercrossing of landraces from clusters with high intercluster euclidean distance groups would produce highly segregating population for days to heading, maturity, grain filling period, plant height, thousand-grain weight and grain yield. Landraces in high yielding clusters are characterized by early flowering, long grain-filling period, medium plant high and high thousand-grain weight as opposed to their low yielding cluster groups containing late heading, short plant height and lower thousand-grain weight. Relatively early heading and maturing landraces produced higher yield and thousand–grain weight during the belg barley production system of Ethiopia.Negative correlation coefficient between grain yield and day to maturity under drought condition [8]. . Landraces with taller plant height give better grain yield in unpredictable rainfall cropping season. This finding is supported by Acevedo *et al.* [9], who reported that tall barley genotypes are yielded better in low-rainfall Mediterranean areas. The positive contribution of plant height to grain yield is also mentioned by Alam *et al.* [10].

CONCLUSION

The variability among the tested 181 barley landraces is sufficient enough to exercise selection for high yielding and early maturing landraces that are desperately needed in the *belg* barley production system of Ethiopia. So, successive evolution of promising landraces from the high yielding clusters in the past ten years resulted in the development of two early maturing and high yielding varieties nationally certified for the commercial production in the study areas and similar production systems in Ethiopia. Moreover, landraces from both clusters have been maintained for further characterization, hybridization and subsequent evaluation of the segregating population for lodging resistant and high yielding potential under high rainfall and potential barley growing areas of Ethiopia. Earlier heading, medium plant height and higher thousand-grain weight barley landraces from clusters I, III, IX, II, X and V are potential donor parent in breeding for early maturity and high yielding, whereas short plant height and late maturing counterparts from VI, IV, VIII and VII may be used as donor parent in breeding for high potential areas. Crossing landraces from I, III, IX, II, X and V and cluster VI, IV, VIII and VII and selecting the subsequent segregating population for the development of recombinant inbred lines is possible in the future barley breeding endeavours. It is also important to note that the landraces should not be banned as they are not exhaustively evaluated for biotic and abiotic stresses resistance, food and feed values related traits.

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