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EVALUATION OF CENTRAL ANATOLIAN BARLEY LANDRACES FOR CROP IMPROVEMENT

Necdet Akgun[1*], Ali Topal[1], and Mevlut Akcura[2]

[1]Selcuk University, Agricultural Faculty, Konya,Turkey
[2]Bingol University, Agricultural Faculty, Bingol,Turkey
*Corresponding author. E-mail: nakgun@selcuk.edu.tr; nakgun2009@gmail.com

ABSTRACT

This study was conducted to characterize 201 two-rowed barley accessions, collected from 11 provinces of Central Anatolian Region of Turkey by quantitative and qualitative traits and to develop pure lines by selecting for yield and quality traits. Experiments were carried out in Konya dry conditions.

In the first year of the study (2007-2008) these accessions and 3 checks were studied by Augmented Design. In the second year (2008-2009), 696 single plants selected in the first year and the same control varieties were planted in plant rows by Augmented Design, and grain yield and some yield and quality components were measured. In the third year (2009-2010) 174 pure lines selected in the second year with 13 control varieties were tested by Augmented Design. The characters measured included grain yield, protein ratio, thousand grain weight, test weight, heading time and plant height. Compared with control varieties, some pure lines showed superiority with respect to these characters. According to the research results, 11 two-rowed barley lines with the yield and qualitative features desired for consumers can be offered for crop improvement.

Key words: Barley landraces, characterization, pure line, selection.

INTRODUCTION

Global demand and consumption of agricultural crops, particularly cereals, for food and feed is increasing at a rapid pace. This demand for plant materials has been expanding for many years (Edgerton, 2009). Crop breeding efforts are aimed at increasing the yield and economic value by incorporating disease and insect resistance, better grain quality and shorter growth duration traits to avoid dry period. To efficiently utilize genetic resources in plant-breeding programs it is first necessary to determine whether useful genetic variation exist in the material and, secondly, to develop the most cost-effective method of introducing the potentially useful genes into commercially acceptable material (Kearsey, 1997). Barley-improvement programs, whether by breeding or direct gene manipulation, aim to match adaptation to the local environment and to enhance quality for processing (Ellis, 2002).

Barley landraces are genetically closer to modern cultivars than to wild barley, but, even so, extensive breeding is necessary to assemble favourable alleles into appropriate linkage blocks (Thomas et al., 1998). Landraces exist worldwide and represent a source of useful alleles, as they often perform more stably over a range of conditions than do modern cultivars (Ceccarelli, 1996). This advantage of barley landraces may be partially explained by their buffering ability, wherein better-adapted individuals of the population compensate for the losses of less-adapted plants under adverse conditions (Akinci and Yildirim, 2009).

The objectives of this study were to present the results of the phenotypic and genetic diversity in barley landraces of Central Anatolian region of Turkey and to isolate by direct selection agronomical superior lines from landraces with drought- and heat-resistance suited to modern input conditions.

MATERIALS AND METHODS

This study was conducted to characterize 696 barley landraces, selected from 201 two-rowed barley accessions collected from 11 provinces of Central Anatolian Region of

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Turkey. The phenotypes scored were row type and seed (lemma) color. Site of collection, number of landraces and seed colour of the barley genotypes are given in Table 1. The accessions were tested at Selcuk University Experimental Field (Konya, Turkey). Experimental Field (36º41′-39º16′ E and 31º14′-34º26′ N, 1016 m of altitude) is located in the Central Anatolia of Turkey. The annual average of the total precipitation is 320 l/m^2 in a year most falling between October and June with peaks in December and May (Figure 1). The temperature ranges from 27.6^{0}C to -3.5^{o}C (Figure 2) with the soil type classified as Clay loam with a pH of 8.00.

In the 2007-2008 (first year) growing season, each barley accession was sown on four-rowed plots, 1 m in length and spaced 20 cm apart.

Table 1. Details of 11 barley landraces populations used in the study

Entry code	Province	Number of landraces	Color of husk on grain		
			White	Grey	Black
1	Konya	556	359	87	110
2	Karaman	13	13	-	-
3	Ankara	9	4	4	1
4	Sivas	78	61	17	-
5	Aksaray	5	5	-	-
6	Çankırı	6	6	-	-
7	Kırşehir	4	4	-	-
8	Yozgat	11	10	1	-
9	Niğde	4	4	-	-
10	Eskişehir	8	8	-	-
11	Kayseri	2	2	-	-
	Total	696	476	109	111

After single plant selection during this year, a field experiment was established in 2008-2009 (second year) to evaluate the 696 barley genotypes, together 3 checks. Each plot consisted of one row, 1 m in length and sown 0.2 m apart. A total of 174 entries were selected. In 2009-2010 (third year) the plot size was as in the first year. The trial included all 174 barley lines selected from the second-year evaluations and 13 checks. Each year, plots were sown by augmented design in the beginning of October and received 60 kg ha^{-1} N in two applications and 65 kg ha^{-1} P_2O_5. Days to heading were recorded from the 1st of January till the moment when 50% of the spikes had emerged from the boot. At maturity, plant height was measured from the soil surface to the top of the spikes excluding the awns. A sample of 10 tillers was harvested randomly from each plot to measure the yield components. The remaining plants in each plot were harvested by hand. Protein content of the grain was determined with a LECO TruSpec CN protein analyser. Results were analysed using SAS/Stat User's guide (SAS Institute Inc.).

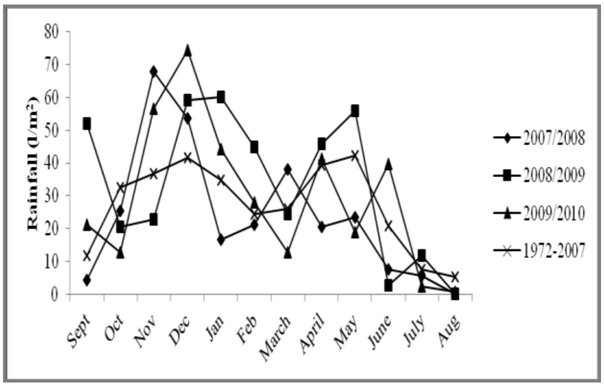

Figure 1. Monthly rainfall data of the experimental field

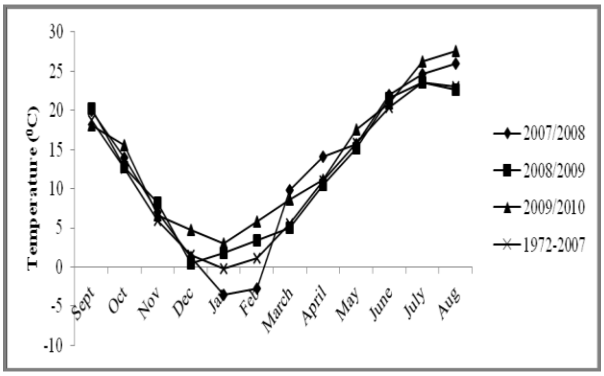

Figure 2. Monthly temperature data of the experimental field

RESULTS

Colour of husk on grain of the 696 barley landraces are listed in table 1. Most have white-coloured seed (68%), followed by black (16%) and grey (16%). The range of values for all investigated traits, especially grain yield, was large for all populations (Table 2). Grain yield were 11.0-427.6 g m^{-1} among the landraces. The grain yield of population 9 was 14% higher than the overall population mean, and the other traits of this population were also higher than the population means. The genotype producing the highest grain yield

(427.6 g m^{-1}) was found in population 1. The earliest population was population 11 (109 days to heading), while the latest were populations 7 and 9 (130 days). In the comparison of the means of the landraces genotypes with those of the controls, the landraces showed higher grain yield and were earlier than the controls. Controls were superior to landraces for 1000-kernel weight. The plant growth habit of landraces is shown in Table 2. Seventy-five percent of all landraces used in this study were with prostrate growth habit and 16% were with erect growth habit.

Table 2. Means and ranges for agronomic traits and growth habit values of 11 barley landraces in the 2008-2009 growing season

Entry code	Plant height (cm)	Spike length (cm)	Spikelets $spike^{-1}$	Kernels $spike^{-1}$	1000-kernel weight (g)	Grain yield (g m^{-1})	Heading time (d)	Plant growth habit*		
								1	2	3
1	131.0 (83.3-145.7)	9.0 (5.1-13.0)	30.2 (16.5-38.0)	28.7 (16.3-36.0)	40.5 (21.5-76.8)	118.3 (11.0-427.6)	124 (108-138)	475	48	33
2	134.8 (129.6-142.3)	8.2 (7.4-9.7)	30.0 (27.5-32.5)	28.6 (26.0-31.2)	41.2 (30.0-46.6)	103.5 (69.2-144.2)	129 (128-130)	13	0	0
3	120.3 (102.3-135.0)	9.5 (7.6-10.9)	29.3 (24.0-34.0)	27.7 (20.0-34.0)	40.9 (31.8-58.3)	123.8 (44.2-182.6)	121 (107-130)	2	7	0
4	121.0 (89.6-142.1)	8.5 (4.9-10.3)	27.8 (18.0-34.0)	25.9 (16.2-33.0)	39.6 (22.6-59.5)	101.2 (20.6-300.1)	115 (107-130)	11	3	64
5	140.3 (135.2-146.3)	8.4 (7.4-9.7)	30.1 (29.0-34.0)	28.8 (28.0-31.0)	42.2 (32.6-46.5)	117.6 (29.4-144.5)	126 (124-128)	5	0	0
6	123.4 (105.2-135.5)	11.0 (8.1-15.5)	30.3 (24.5-32.0)	25.8 (22.0-31.0)	38.8 (22.2-49.0)	110.7 (35.1-151.5)	119 (109-130)	3	3	0
7	139.8 (138.8-141.0)	8.0 (6.8-9.2)	29.0 (25.5-32.0)	27.2 (24.0-30.7)	41.1 (35.3-45.6)	130.2 (87.5-153.0)	130 (129-130)	4	0	0
8	124.7 (114.9-142.1)	9.4 (8.0-10.5)	26.3 (24.0-31.0)	23.4 (19.5-29.0)	32.5 (25.1-43.4)	67.6 (25.1-143.3)	111 (109-134)	0	0	11
9	139.4 (138.5-140.3)	9.1 (8.2-9.9)	31.6 (30.0-34.0)	30.2 (28.5-32.5)	48.4 (46.8-50.0)	131.8 (103.6-160.1)	130 (129-130)	4	0	0
10	135.8 (133.0-140.3)	8.7 (7.5-9.3)	31.0 (25.0-32.0)	29.8 (23.0-31.2)	43.5 (33.8-50.6)	102.9 (65.5-123.3)	129 (128-131)	8	0	0
11	98.6 (97.6-99.5)	7.7 (6.9-8.6)	26.2 (24.5-28.0)	24.3 (23.0-25.7)	29.8 (28.6-31.0)	65.2 (42.2-88.3)	109 (108-109)	0	0	2
Mean	129.8	8.9	29.9	28.3	40.4	115.2	123	525	62	109
Checks	135.6	8.5	30.2	29.1	44.9	102.4	129		Totals	

*1- prostrate; 2- intermediate; 3- erect growth habit.

A dendrogram showing the phenotypic relatedness of the barley landraces populations based on agronomic traits is presented in Figure 3. The populations are clustered in four groups at a linkage distance of 35.0, of which the first two groups (I and II) are larger than others two (III and IV) groups. Member subpopulations within each group were also separated at linkage distances ranging from 3.0 to 26.6, with populations 2 and 10 in group III being the closest and populations 8 and 11 in group IV being the farthest apart. In fact, the two barley populations in group IV are out-grouped from the rest, each of them on the next highest level of clustering. Group I consists of populations (7 and 9) with the longest heading time (130 days) and prostrate growth habit, while group IV comprises the landraces with the shortest heading time and erect growth habit. This shows that some plant characters can strongly affect grouping, probably because of linkage to some of the traits scored. However, this was not the case with the other analysed traits of landrace populations. Therefore, genotypes with different awn-dent and spike form were randomly distributed among all clusters/subclusters. Moreover, landrace populations in group I had a longer heading time, longer spike length, higher spikelet number and grain yield. For all that landraces in group III had a higher kernel number per spike, higher 1000-kernel weight and longer heading time than the II group, their grain yields were under 104 g m^{-1}.

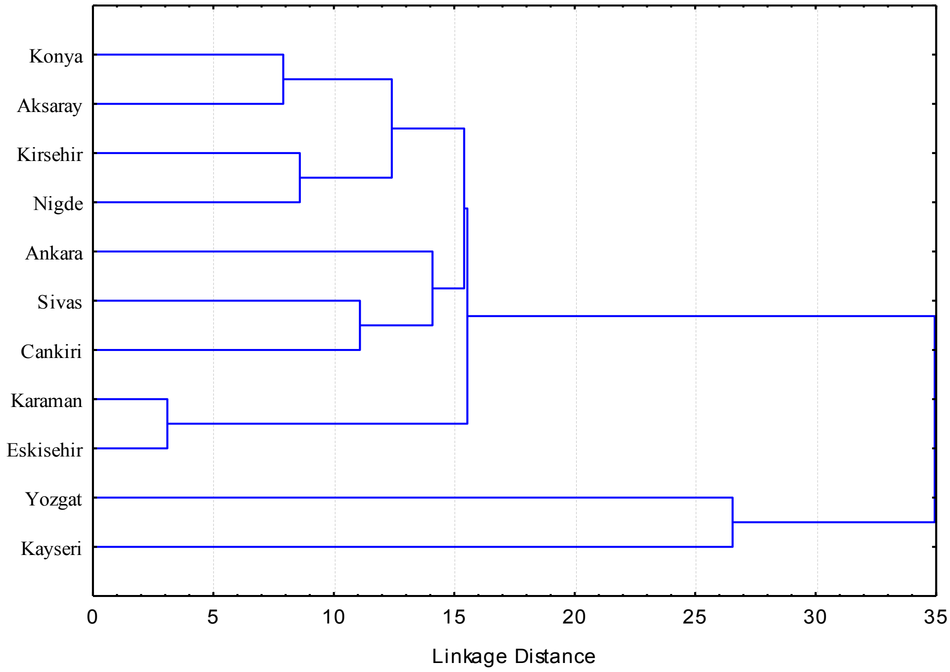

Figure 3. Dendrogram of 11 Central Anatolian landraces populations based on agronomic traits of the 2008-2009 growing season

Table 3. Means for some traits of selected barley landraces and checks in the 2009-2010 growing season

Entry code	Plant height (cm)	Heading time (d)	Protein concentration (%)	Test weight (kg)	1000-Kernel weight (g)	Grain yield (kg ha^{-1})
T747-4	100.0	117	15.11	69.82	44.79	7133
T750-1	94.4	119	14.09	61.79	55.79	5574
T746-2	90.3	115	17.89	51.98	45.56	4899
TR71960-2	100.0	118	12.83	65.99	47.69	4517
T794-1	92.2	117	14.08	67.72	48.89	5092
TR71982-1	101.2	118	15.15	65.66	38.79	5140
T733-1	88.1	116	16.03	64.00	45.42	4504
T724-2	94.1	113	12.08	59.17	46.36	5019
T722-1	94.3	117	12.19	56.25	39.96	4902
A713-3	108.9	110	13.60	65.58	35.09	4070
A77-2-3	85.4	103	9.56	67.58	40.49	3768
Mean	95.4	115	13.87	63.23	44.44	4965
Checks mean	92.6	120	12.89	60.65	44.06	4067
Selected mean	90.9	113	10.83	60.14	41.55	3672

After evaluation of 696 barley landraces for all the investigated traits, especially grain yield and heading time, 174 barley genotypes were selected and sown during 2009-2010 growing season. The characters measured included plant height, heading time, protein concentration; test weight, thousand grain weight and grain yield (Table 3). When compared with the control checks means, the landraces showed lower mean values for all traits. However, some genotypes showed superiority with respect to some characters. Forty-nine landraces had higher grain yield than the mean of controls, 11 being superior to the highest control. For protein concentration 16 landrace genotypes were superior to the highest control, while 19 genotypes were over the highest control for 1000-kernel weight. As a result, 11 barley landrace lines, which had desirable properties for all traits according to their individual performances (Table 3), were selected to be used for further variety improvement.

DISCUSSION

Current study, detecting high genetic variation for the investigated morphological characters and grain yield, indicated that the barley landraces from Central Anatolian region of Turkey may be useful in selection and breeding programs. According to Marshall and Brown (1975) and Oka (1975), the numbers of genotypes (696) used in this study are sufficient to include all genetic variation under most circumstances. Similar high variation with the south-eastern Turkey barley landraces was observed by Kiran (1997) and Akinci and Yildirim (2009), and in different regions such as Syria (Parzies et al., 2000), Ethiopia (Alemayehu and Parlevliet, 1997; Lakew et al., 1997) and Oman (Jaradat et al., 2004). The predominant phenotypic class in most of our landraces, which has the two-row type and white seed colour, differed from south-eastern Turkey barley landraces, which displayed generally the two-row type and grey seed colour (Akinci and Yildirim, 2009). Many authors (Negassa, 1985; Demissie and Bjornstad, 1996) noted that the two-rowed spike types were concentrated in barley-growing areas with moisture stress, and the relative abundance of the six-rowed barley types in areas receiving a higher amount of rainfall is therefore not surprising. The abundance of white kernel color in this study was confirmed by an investigation by Jaradat et al. (2004) on Oman barley landraces. Their study revealed that the grey kernel colour had the second highest frequency. Detailed information about barley landraces from the western and central parts of Turkey was reported by Somarro et al. (1986). According to those authors, 716 Turkish barley landraces had the following traits, expressed in mean values: heading time, 139 days; plant height, 77.6 cm; number of spikelets, 24; 1000-kernel weight, 40.1 g and percentage of protein, 11.7. The values we found for plant height and number of spikelets was higher than those observed by Somarro et al. (1986); all other traits had similar values. Such genetic differentiation among barley populations is a predicted consequence of its breeding system (Lakew et al., 1997). In our study, the grain yield of selected landraces lines under dry conditions was on average lower than for control checks. Landraces were not successful under high-rainfall conditions during this growing season and a high-humidity environment. In particular, lodging is a main problem for barley landraces in high-rainfall seasons (Ahokas and Poukkula, 1999). This result showed that landraces adapted to drought conditions during a very long natural selection process.

Some researchers have used certain simply inherited morphological characters before assessing genetic diversity in barley and for testing the distinctiveness of genotypes (Brown and Munday, 1982; Allard, 1992). In contrast, we used quantitative traits such as heading time, grain weight and grain yield, but mainly earliness and grain yield, to select for superior lines (Table 3). Consequently, we conclude that the high yield in our landraces is associated with earliness and grain weight. In addition, the variation between spike traits can contribute to grain yield and stress tolerance, and make better use of different ecological conditions. Jaradat et al. (2004) reported a very large phenotypic diversity index for some spike traits such as spike density, spike length, spikelet number, spike weight, and seed number per spike of Oman barley landraces. The results of our study confirm that morphological and developmental traits are good descriptors for differentiating barley germplasm accessions. This conclusion confirms the result from

Akinci and Yildirim (2009) and Weltzien (1989), who studied barley accessions from the South-eastern Turkey and the Near East region, respectively. In their studies of a group of highly variable barley accessions, qualitative traits, including those we observed, can be used for agronomic evaluation and utilization of germplasm collections.

CONCLUSIONS

Some promising lines were identified by using the variation within locally adapted barley germplasm of Central Anatolian region. These superior lines could be released as cultivars to achieve increases in both grain yield and quality. They could also be used in breeding programs as potential donors of useful genes. We have confirmed the presence of individual genotypes within landraces which have a yield potential comparable with the control checks. The genetic variability existing in these landraces, as well as some specific traits, may be transferred in backcrossing programs. As a next step, a comprehensive genetic analysis of these landraces will characterize the allelic content and value of these genetic resources. Sources of disease resistance within the same sample of landraces lines used in the selection program should be identified by further research. These observations have a clear bearing on the collection and maintenance of barley landraces. Here we are proposing to make full use of the adapted genetic background of landraces within their area of adaptation and only to add those few genes which can improve them.

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