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Full Length Research Paper

Multivariate Insights into Genetic Variability of Durum Wheat Landraces under Diverse Irrigation Regimes

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To evaluate the genetic diversity in 37 durum wheat landraces originated from Iran and Azerbaijan, an experiment based on randomized complete block design with three replications was carried out in normal irrigation and drought stress conditions in agricultural research station of Islamic Azad University, Ardabil, Iran. Analysis of variance indicated that there were highly significant differences among the genotypes in all of the traits. Environment mean squares were significant for all the traits studied showing that the drought stress has significant effect on all the traits. The heritability estimates were high for plant height in both conditions. In regression analysis (stepwise method) under stress, number of grains per spike and plant height remained in final model (R^2 = 0.634). In well-watered condition biological yield, awn length and harvest index showed more direct positive effects on yield. In drought stress condition, biological yield, spike length, number of grains per spike and harvest index showed more direct positive effects on yield. Harvest index showed the highest indirect effect on yield in two conditions. Cluster analysis, divided the genotypes into three groups in each condition. Classifying the results of the cluster analysis identified bagh oliya, naxcevan and chakmak genotypes in stress condition which confirm the results of the compared means yield.

Key words: Genetic diversity, heritability, landrace, path analysis, yield.

INTRODUCTION

Many modern cultivars, in wheat and in other crops as well, are often genetically similar, with a rather narrow genetic base. Therefore, in breeding we need to also utilize sources of new diversity. Landraces, which have arisen through a combination of natural selection and the selection performed by farmers (Dotlacil et al., 2010), usually have a broader genetic base and can, therefore, provide valuable characteristics important for breeding (Tesemma et al., 1998; Dotlacil et al., 2010). Therefore, it is necessary to investigate genetic diversity in the currently used wheat germplasm in order to maintain a desirable level of genetic variation in future wheat breeding (Maqbool et al., 2010). The development of high yielding wheat cultivars is a major objective in breeding programs (Ehdaie and Waines, 1989). The genetic variation for the trait under selection and a higher heritability are necessary to have response to selection (Kahrizi et al., 2010). Considering that yield is polygenic and its heritability is height to achieve high yield, selection is done using yield components (Khayatnejad et al., 2010).

Drought is arising threat of world. Most of the countries of the world are facing the problem of drought. The insufficiency of water is the principle environmental stress and to enter heavy damage in many part of the world for agricultural products (Khan et al., 2010; Nofouzi et al., 2008). Drought stress can reduce grain yield, have estimated the average yield loss of 17 to 70% in grain yield due to drought stress (Nouri-Ganbalani et al., 2009). On the other hand, selection for yield under drought-stress conditions is complicated by low heritability and large genotype-environment interactions (Golabadi et al., 2005). Various morphological and physiological characters contribute to grain yield. Each of these component characters has its own genetic systems.

Further , these yield components are influenced by

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Table 1. Origin and taxonomy of durum wheat landraces tested.

No.	Landraces	Origin	Name	No.	Landraces	Origin	Name
1	Korifla	Control	Korifla	20	Ardabil-samrein	Iran	Apolicum(1)
2	Chakmak	Control	chakmak	21	Ardabil	Iran	Apolicum(2)
3	Zardak	Control	Zardak	22	Germi-moghoan	Iran	Hordeiforme(1)
4	Haurani-1	Control	Haurani-1	23	Germi-langin	Iran	Melasnopus(1)
5	Omrabi-5	Control	Omrabi-5	24	Naxcevan	Azerbaijan	Boeufii(2)
6	Germi-langin	Iran	Niloticum	25	Naxcevan	Azerbaijan	Africanum(3)
7	Ardabil-samrein	Iran	Albobscurum	26	Naxcevan	Azerbaijan	Leucumelan(1)
8	Germi-langin	Iran	No-name	27	Lerik	Azerbaijan	Leucumelan(2)
9	Germi-langin	Iran	Riechenbachii(G1)	28	Naxcevan	Azerbaijan	Leucurum(3)
10	Germi-moghoan	Iran	Riechenbachii(G2)	29	Xanlar	Azerbaijan	Murciense(2)
11	Kordgheshlaghi	Iran	Albiprovinciale(1)	30	Guba	Azerbaijan	Hordeiforme(2)
12	Germi-langin	Iran	Albiprovinciale(2)	31	Xatmaz	Azerbaijan	Murciense(3)
13	Germi-langin	Iran	Melaleucum	32	Naxcevan	Azerbaijan	Boeufii(3)
14	Ahar	Iran	Leucurum(1)	33	Gux	Azerbaijan	Leucurum(4)
15	Ardabil-bagh oliya	Iran	Leucurum(2)	34	Ardabil	Iran	Hordeiforme(3)
16	Germi-boldash	Iran	Murciense(1)	35	Ardabil	Iran	Melasnopus(2)
17	Germi-langin	Iran	Boeufii(1)	36	Shamaxi	Azerbaijan	Hordeiforme(4)
18	Germi-langin	Iran	Africanum(1)	37	Naxcevan	Azerbaijan	Leucurum(5)
19	Sari boghda	Iran	Africanum(2)				

environmental fluctuations.

Therefore, it is necessary to separate the total variation into heritable and non-heritable components with the help of genetic parameters, that is, genotypic and phenotypic coefficient of variation, heritability and genetic gain (Kahrizi and Mohammadi, 2009; Maniee et al., 2009). Morphological characters such as number of tillers, grain per spike number, fertile tillers number per plant, 1000 grain weight, peduncle length, awn length, plant height, spike length, kernel number per spike, grain weight per spike and etc. affect the wheat tolerance to the moisture shortage in the soil (Blum, 2005; Nouri-Ganbalani et al., 2009; Aminzadeh, 2010). According to path analysis in durum wheat genotypes, number of seeds per spike, 1000 seed weight and number of tillers have direct and positive affects yield (Monral et al., 1997; Simane et al., 1993). Kumar and Gupta (1984) reported direct positive but little affect of plant height, number of seeds per spike, 1000 seed weight and number of tiller on yield.

The purpose of this research was the investigation of genetic diversity in durum wheat landraces, determining effective traits on yield under drought and non stress conditions.

MATERIALS AND METHODS

In order to study the genetic diversity of durum wheat, 37 durum wheat (*Triticum durum* Desf.) landraces from Iran and Azerbaijan republic were evaluated under irrigated and non-irrigated conditions (Table 1). Base on randomized complete block design with three replications. The experiment was carried out in agricultural research station of Islamic Azad University, Ardabil branch, Iran (Northwest of Iran), during the 2009 and 2010 cropping year. Plot size was 7 x 1.2 m. Standard cultural practices were followed for raising the crop. The studied characters were plant height, number of tillers, peduncle length, spike length, grain per spike numbers, fertile tillers per plant, 1000 grain weight, awn length, kernel per spike, harvest index and grain yield.

The analysis of variance (ANOVA) for each character was performed followed by Duncan's new multiple range test (Steel and Torrie, 1960) to test the significance difference between means. The data were statistically analyzed by path analysis and SPSS software's. The mean squares were used to estimate genotypic and phenotypic variance according to Johnson et al. (1955). The genotypic and phenotypic coefficient of variation and heritability were calculated according to the formula used by Hallauer and Miranda (1981). The genetic correlation between traits, heritability and K^2G (= G_{22}/G_{11}) [G_{22} = genetic variance of trait x in stress environment. G_{11} = genetic variance of trait x in non-stress environment] for every trait and percent of variation of traits were computed from Golabadi et al. (2005).

RESULTS AND DISCUSSION

Analysis of variance of data showed that there is considerable variability among genotypes in all of the traits, demonstrating the presence of genetic diversity among landraces under study. Environment mean squares were also significant for all the traits studied, showing that the water stress has significant effect on all traits. G x E interaction was significant for all the traits except for spike length, awn length and biological yield, showing variation of genotypes over environments (Table 2). This could provide scope for breeding for traits

Table 2. Mean squares of components 37 durum wheat genotypes under normal irrigation and drought stress condition.

S.O.V	df	Means square										
		No. of tillers	Fertile tillers per plant	Plant height	Spike length	Peduncle length	Awn length	No. of grain spike	1000 grain weight	Grain yield	Biological yield	Harvest index
Replication	2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	***	***
Condition	1	***	***	***	***	***	***	***	***	***	***	***
Genotype	36	***	***	***	***	***	***	***	***	***	***	***
C × G	36	*	***	***	Ns	***	Ns	**	***	**	Ns	***
Error	146	0.513	0.345	22.315	0.19	14.456	0.706	26.918	34.832	0.255	15.547	45.78

***, **,* and Ns, significant at P < 0.0001, 1%, 5% level of probability and non-significant, respectively.

studied, along with yield and its components, under drought stress conditions. Mean performance for all the traits decreased in drought stress environment except harvest index (Table 3).

Mean value for Tillers number, fertile tillers number, plant height, spike length, peduncle length, awn length, grains per spike, 1000 grain weight, biological yield and grain yield decreases 16.6, 31.2, 15.6, 6.44, 23.8, 6.61, 13.5, 12, 29.4 and 15.8%, respectively. Similar results were reported by other researchers (Nouri-Ganbalani et al., 2009; Golabadi et al., 2005; Khayatnejad et al., 2010). Mean comparison of Genotypes, showed that genotypes 9, 20, 12, 4, 23, 8, 30, 19, 22, 33, 17, 14, 3, 28, 16, 37, 1, 25, 29 and 15 had the highest tiller numbers in non-stressed condition. Genotype 1, 33, 17, 4, 28, 8, 12, 15, 19, 20, 37, 27, 10, 16 and 2 had the highest of this trait in stressed condition (Table 4). Although, genotypes 33, 28, 8, 15, 19, 37 and 16 were resistant in two condition but interaction G × C related to genotypes 4, 12, 20, 10 and 2 in stressed condition and 23, 30, 25, 14 and 3 in non-stressed condition.

The highest fertile tillers number per plant was determined in genotypes 4, 1, 3, 22, 2, 33, 20 and 14 in non-stressed. Under stressed condition, genotypes 10, 33, 28, 17, 27, 37, 25, 4, 15, 9 and 16 had the highest fertile tillers number (Table 4). This difference had in selection genotypes in fertile tillers number per plant under two conditions express interaction G × C, except genotype 33. Mean comparison of genotypes also showed that genotypes 9, 10, 16 and 21 were, the tallest and genotypes 4, 8 and 23 had the lowest plant height in non-stress. Under stressed condition, genotypes 9 and 16 had the highest plant height and the lowest plant height was specified in genotypes 12 (Table 4). Genotype 10 had the highest spike length and the lowest spike length in genotypes 12 and 23 in two conditions (Table 4). Results for spike length in two conditions are similar that support non-significant G x E interaction.

The highest peduncle length was determined in genotypes 9 and 21 and the lowest peduncle length in genotypes 4, 3, 8, 24, 12 and 23 in non stress condition.

Under stress condition, genotypes 16, 21, 7 and 9 had the highest peduncle length and the lowest peduncle length was specified in genotypes 3 and 5 (Table 4). Genotypes 28, 10, 27, 9 and 26 had the highest awn length in non-stressed condition. Genotypes 10, 27, 28, 9 and 26 had the highest awn length in stress condition (Table 4).

Genotypes 24, 27, 25, 26 and 28 had the highest number of grains/spike in non- stressed condition. Genotypes 28, 9, 26, 27, 29, 32, 33 had the highest no. of grain spike in stress condition (Table 4). Genotypes 9, 10, 6, 16, 17, 18, 21, 25, 26, 29, 33, 36 and 37 had the highest biological yield in non-stressed condition. Genotypes 10, 17, 18, 26, 33 and 37 had the highest biological yield in stress condition (Table 4). Existence non-significant G x E interaction led to similar genotypes with high biological yield in two conditions. The highest 1000 grain weight was determined in genotypes 1 and 8 in non-stress condition. Under stress condition, genotypes 2 had the highest 1000 grain weight (Table 4). Genotypes 1, 3, 2, 27, 13, 20, 22 and 28 had the highest harvest index in non- stressed condition. Genotype 28 had the highest harvest index in stress condition (Table 4).

Guttrieri et al. (2001) reported that selection of drought tolerant genotypes leads to reconnaissance genotypes with high 1000 grain weight. Genotypes 1, 3, 2, 28 and 26 had the highest yield in non-stressed condition. Genotypes 2, 15, 26, 29 and 28 had the highest yield in stress condition (Table 4). Outrank yield in genotypes 1 and 3 in non-stress due the high total no. of tillers, fertile tillers number per plant and

Table 3. Range, mean, percentage decrease, heritability and K^2G under drought stress (C2) compared with normal irrigation conditions (C1) in durum wheat genotypes.

Traits	Condition	Range	Mean ± S.E.M	% decrease	H2B. (%)	K2G
No. of tillers	C1	4.0	5.62 ± 0.11	16.6	47.69	0.63
	C2	3.0	4.68 ± 0.08		52.86	
Fertile tillers per plant	C1	5.0	4.09 ± 0.11	31.2	69.98	0.44
	C2	4.0	2.81 ± 0.07		61.47	
Plant height	C1	91.3	98.2 ± 2.12	15.6	94.52	0.85
	C2	82.2	82.9 ± 1.93		96.13	
Spike length	C1	7.33	7.41 ± 0.15	6.44	93.54	0.89
	C2	6.67	6.94 ± 0.15		91.97	
Peduncle length	C1	48.1	48.1 ± 1.01	23.8	85.13	0.93
	C2	47.1	36.6 ± 0.94		89.17	
Awn length	C1	11.2	12.8 ± 0.25	6.61	90.21	0.95
	C2	11.8	12.0 ± 0.24		89.53	
No. of grain spike	C1	56.8	39.1 ± 1.49	13.5	92.14	0.81
	C2	50.0	33.8 ± 1.38		87.54	
1000 grain weight	C1	57.1	66.2 ± 1.13	12	76.32	0.62
	C2	48.9	58.2 ± 0.95		64.89	
Biological yield	C1	32	24.5 ± 0.75	29.4	70.83	0.9
	C2	31.8	17.3 ± 0.68		74.53	
Grain yield	C1	3.52	4.63 ± 0.07	15.8	51.46	1.04
	C2	3.2	3.89 ± 0.06		58.38	
Harvest index	C1	60.2	21.5 ± 0.93	-26.1	55.71	2.91
	C2	75.4	27.1 ± 1.33		73.81	

Table 4. Mean of yield components each genotype in normal irrigation (C1) and drought stress (C2) conditions.

No.	Landraces	No. of tillers		Fertile tillers per plant		Plant height		Spike length	
		C1	C2	C1	C2	C1	C2	C1	C2
1	Korifla	6 A-D	6.00 A	6.00 AB	2.66 C-E	103.2 E-H	63.11 OP	5.9 K-L	5.62 O-Q
2	Chakmak	5.33 B-F	5.00 A-D	5.33 A-D	3.00 B-D	99.83 E-I	67.95 NO	10.20 B	9.5 AB
3	Zardak	6.33 A-C	4.66 B-E	5.66 A-C	2.00 DE	60.92 LM	53.01 QR	6.91 IJ	6.383 L-O
4	Haurani-1	7.00 A	5.66 AB	6.33 A	3.33 A-C	49.9 N	54.85 QR	5.86 KL	5.05 Q
5	Omrabi-5	4.66 D-G	4.66 B-E	3.33 G-J	1.66 E	99.27 E-I	58.16 PQ	6.00 K	5.192 Q
6	Germi-langin	5.33 B-F	4.33 C-F	4.00 E-H	3.00 B-D	126.1 B	110.3 BC	7.75 F-H	7.45 G-J
7	Samrein	4.33 E-G	4.33 C-F	3.33 G-J	3.00 B-D	122.2 BC	110.7 BC	8.65 C-E	8.55 C-E
8	Germi-langin	6.66 AB	5.66 AB	2.66 IJ	2.33 C-E	55.44 MN	53.38 QR	6.23 JK	5.075 Q
9	Germi-langin	7.00 A	4.66 B-E	5.00 B-E	3.33 A-C	137.1 A	119.1 A	9.15 C	9.15 BC
10	Moghoan	5.00 C-G	5.00 A-D	4.66 C-F	4.03 A	129.8 AB	112.5 B	11.41 A	10.2 A
11	Kordgheshlaghi	4.66 D-G	3.66 E-G	3.66 F-I	2.33 C-E	96.97 F-I	84.13 H-J	5.73 KL	5.483 PQ

Table 4. Contd.

12	Germi-langin	7.00 A	5.33 A-C	3.33 G-J	2.66 C-E	68.6 L	49.87 R	4.6 M	4.3 R
13	Germi-langin	5.33 B-F	4.33 C-F	4.33 D-G	2.33 C-E	90.37 IJ	67.65 NO	5.867 KL	5.645 O-Q
14	Ahar	6.33 A-C	4.00 D-G	5.33 A-D	2.00 DE	91.6 IJ	75.52 K-M	5.63 KL	5.392 PQ
15	Bagh oliya	5.66 A-E	5.33 A-C	3.00 H-J	3.33 A-C	80.4 K	76.5 KL	7.31 HI	6.85 I-M
16	Germi-boldash	6.00 A-D	5.00 A-D	4.00 E-H	3.33 A-C	129.3 AB	123.3 A	10.42 B	9.05 BC
17	Germi-langin	6.33 A-C	5.66 AB	5.00 B-E	4.00 AB	120.4 BC	105.6 BC	8.3 D-F	7.85 E-G
18	Germi-langin	5.00C- G	4.33 C-F	2.66 IJ	2.33 C-E	114.8 CD	94.2 EF	8.6 C-E	8.35 C-F
19	Sari boghda	6.33 A-C	5.33 A-C	4.00 E-H	2.33 C-E	93.1 HI	80.08 I-K	5.2 LM	5.217 Q
20	Samrein	7.00 A	5.33 A-C	5.33 A-D	3.00 B-D	95.1 G-I	67.5 NO	5.7 KL	5.367 PQ
21	Ardabil	4.33 E-G	4.33 C-F	3.33 G-J	3.00 B-D	128.4 AB	106.3 BC	8.5 C-F	7.95 D-G
22	Germi	6.33 A-C	4.00 D-G	5.66 A-C	1.66 E	109.2 DE	84.66 G-I	6.2 JK	5.725 N-Q
23	Germi-langin	6.66 AB	4.33 C-F	4.00 E-H	2.66 C-E	57.00 MN	59.33 PQ	4.68 M	4.183 R
24	Naxcevan	4.00F- G	3.66 E-G	2.33 J	2.33 C-E	69.8 L	55.6 QR	8.8 C-E	7.8 E-H
25	Naxcevan	5.66 A-E	4.33 C-F	4.00 E-H	3.33 A-C	104.0 E-G	98.5 DE	8.1 E-G	7.00 H-L
26	Naxcevan	4.66D-G	4.33 C-F	3.00 H-J	3.00 B-D	94.05 G-I	97.00 DE	7.32 HI	7.15 G-L
27	Lerik	5.00 C-G	5.00 A-D	4.00 E-H	4.00 AB	97.9 F-I	92.00 E-G	7.5 G-I	7.00 H-L
28	Naxcevan	6.00 A-D	5.66 AB	5.00 B-E	4.00 AB	104.3 E-G	88.65 F-H	7.8 F-H	7.6 F-I
29	Xanlar	5.66 A-E	4.33 C-F	3.00 H-J	2.33 C-E	89.6 IJ	72.15 L-N	6.75 IJ	6.65 J-M
30	Guba	6.66 AB	4.33 C-F	3.00 H-J	2.00 DE	82.17 JK	69.00 M-O	6.94 IJ	6.467 K-N
31	Xatmaz	3.66 G	3.00 G	2.66 I-J	2.00 DE	113.8 CD	103.4 CD	8.65 C-E	8.35 C-F
32	Naxcevan	4.66 D- G	4.66 B-E	4.00 E-H	3.00 B-D	90.8 IJ	92.00 E-G	8.75 C-E	8.35 C-F
33	Gux	6.33 A-C	5.66 AB	5.33 A-D	4.00 AB	105.5 D-F	92.00 E-G	8.12 E-G	7.8 E-H
34	Ardabil	4.66 D-G	3.33 FG	4.00 E-H	1.66 E	125.7 B	81.7 H-K	7.43 GI	6.983 H-L
35	Ardabil	5.33 B-F	4.66 B-E	4.33 D-G	2.00 DE	102.2 E-H	77.11 J-L	6.76 IJ	6.142 M-P
36	Shamaxi	5.00 C-G	4.00 D-G	3.66 F-I	3.00 B-D	99.3 E-I	79.55 I-K	7.81 FH	7.3 G-K
37	Naxcevan	6.00 A-D	5.33 A-C	3.00 H-J	4.00 AB	97.85 F-I	91.3 E-G	8.96 CD	8.7 CD

harvest index traits. So these genotypes had potential for height yield product, fertile tillers and harvest index. Under stress condition, high yield in genotype 28 had been due the high fertile tillers number per plant, awn length and grain per spike number. This genotype improve decrease yield self with increase fertile tillers number per plan and grain per spike number. This genotype in non stress condition had deficiency no. of tillers than other genotypes but in this genotype was highest grain per spike number in two conditions.

We can declare that among the agronomic and morphologic traits, selecting genotypes through 1000-grain weight, grain per spike number, awn length and harvest index affected in improvement yield in stress condition. Broad sense heritability estimates was very high under both control and water stress conditions, for fertile tillers number per plant, spike length, awn length, no. of grain spike and 1000 grain weight broad sense heritability decreased under water stress conditions. While broad sense heritability remained round about constant (increase) for all other traits under both environments (Table 3). Due to higher heritability estimates, great benefits from selection might be expected for all the traits studied (Mehri et al., 2009). However, selection should be made very careful as heritability is measured in broad sense, which may be influent.

In addition to variability parameters correlation studies of these traits may enhance the efficiency of selection. The heritability estimates were high for plant height. Earlier, a high heritability value for plant height was found in durum wheat (Paul et al., 2006; Maniee et al., 2009). High heritability estimates indicate that the selection for these traits will be effective, being less influenced by environmental effects (Maniee et al., 2009). According to Rosielle and Hambblin (1981), if there is a larger genetic variance in a stress environment than in a non-stress one, combined with a high correlation between the two environment ($K^2G > 1$), then selection in the stress environment will raise performance in both environments and will be more effective for this purpose than selection in the non-stress environments. For yield, the amount of K^2G was (1.04) the selection of genotypes can be carried out under non-stress or stress environment because this has $K^2G > 1$. Harvest index showed similar results (Table 3).

Regression and path analysis

In regression analyses using stepwise method under

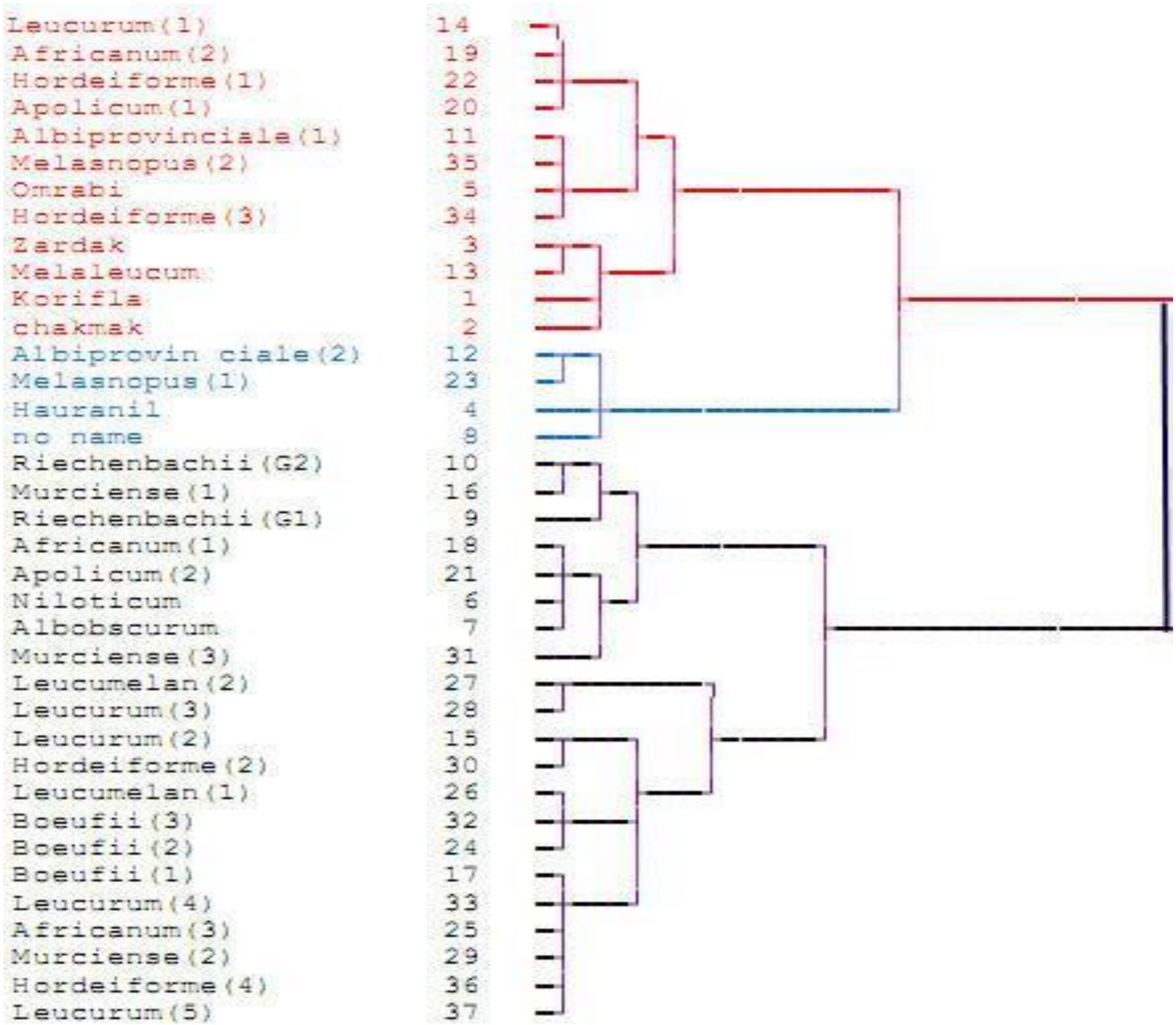

Figure 1. Dendogram of cluster analysis of durum wheat genotypes classified according to all the traits studied in normal irrigation condition.

stress, number of grains per spike and plant height remained in final model, explaining 63.4% of variation in yield (R^2 = 0.634). The results of the path analysis corresponding to the normal and stress conditions are shown in Table 5. In well-watered condition biological yield, awn length and harvest index showed more direct positive effects on yield (Table 5). Harvest index showed the highest indirect effect on yield. In rainfed condition biological yield, spike length, number of grains per spike and harvest index showed more direct positive effects on yield (Table 5). Harvest index also showed the highest indirect effect on yield.

Cluster analysis

Cluster analysis, divided the genotypes into three groups in normal condition (Figure 1). In first group, 1000 grain weight, fertile tillers, harvest index and yield showed maximum deviation from ground mean and this group may recommend as superior groups. Under stress condition in group II awn length, no. of grain spike, no. of tillers, fertile tillers, harvest index and yield showed maximum deviation from ground mean and this group may recommend as superior groups (Figure 2). Classifying the results of the cluster analysis identified

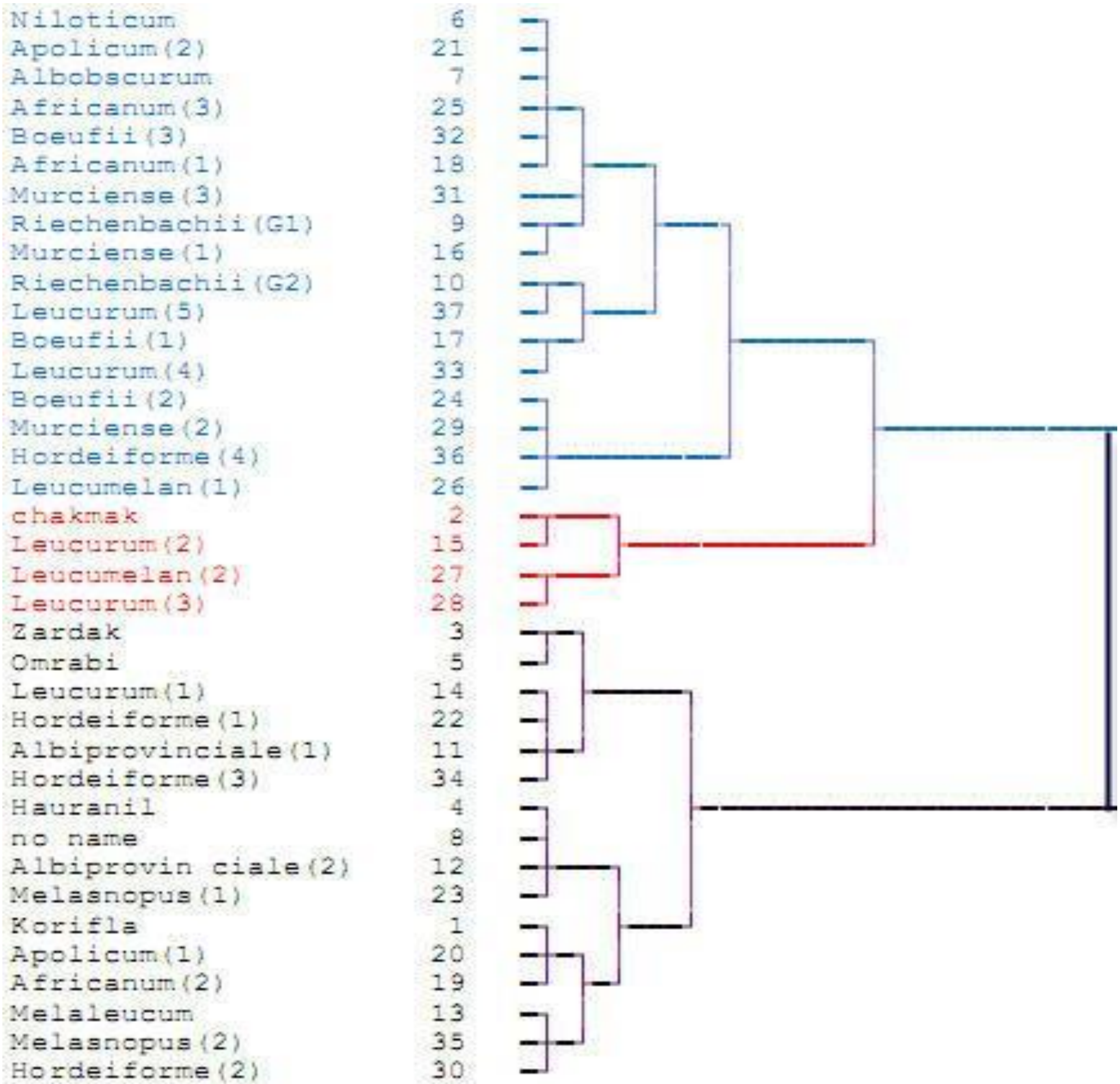

Figure 2. Dendogram of cluster analysis of durum wheat genotypes classified according to all the traits studied in drought stress condition.

bagh oliya, naxcevan and chakmak genotypes in stress condition which confirm the results of the compared means yield. These genotypes could be used as source of germplasm for breeding for drought tolerance.

Conclusions

Therefore, in general, durum wheat landraces grown in North West of Iran and Azerbaijan show the highest genetic diversity in the agronomy traits. As a rule, selection for a agronomic characters narrows genetic diversity these regions wheat escaped this fate because breeding started later in Azerbaijan and Iran than in some other countries and because during the last 40 to 50 years many cultivars breed in other regions have been grown. Therefore, we can use diversity of landraces in

Table 5. The direct and indirect contribution of various characters to yield in durum wheat genotypes.

Traits	Condition	Direct effect	Indirect effect										Total effect
			1	2	3	4	5	6	7	8	9	10	
No. of tillers (1)	Normal	-0.213		0.038	0.129	-0.03	-0.025	-0.113	0.013	-0.199	-0.008	0.265	-0.139
	Stress	0.03		-0.058	0.067	-0.028	-0.008	0.001	-0.006	-0.03	0.01	0.174	0.156
Fertile tillers (2)	Normal	0.083	-0.098		0.037	-0.026	-0.003	-0.055	-0.019	-0.475	-0.021	0.894	0.323
	Stress	-0.101	0.017		-0.214	0.151	0.047	-0.012	0.319	0.172	-0.011	0.037	0.409
Plant height (3)	Normal	-0.365	0.075	-0.009		0.043	0.089	0.176	-0.013	0.497	0.022	-0.489	0.029
	Stress	-0.458	-0.005	-0.047		0.225	0.088	-0.019	0.318	0.239	-0.024	-0.207	0.115
Spike length (4)	Normal	0.072	0.078	-0.03	-0.218		0.048	0.165	-0.021	0.606	0.022	-0.659	0.078
	Stress	0.31	-0.003	-0.049	-0.333		0.063	-0.018	0.359	0.283	-0.02	-0.199	0.398
Peduncle length (5)	Normal	0.094	0.055	-0.002	-0.344	0.037		0.149	-0.008	0.503	0.023	-0.508	0.003
	Stress	0.099	-0.003	-0.049	-0.41	0.198		-0.012	0.302	0.223	-0.032	-0.229	0.093
Awn length (6)	Normal	0.273	0.087	-0.017	-0.235	0.043	0.051		-0.024	0.511	0.016	-0.414	0.296
	Stress	-0.027	-0.002	-0.045	-0.32	0.204	0.043		0.355	0.188	0.005	0.019	0.423
No. of grain spike (7)	Normal	-0.036	0.081	0.043	-0.125	0.04	0.019	0.179		0.476	0.031	-0.576	0.136
	Stress	0.571	-0.001	-0.056	-0.256	0.195	0.052	-0.017		0.244	-0.007	-0.012	0.717
Biological yield (8)	Normal	1.051	0.04	-0.038	-0.173	0.041	0.045	0.133	-0.017		0.036	-1.405	-0.283
	Stress	0.522	-0.002	-0.034	-0.211	0.168	0.042	-0.01	0.267		-0.017	-0.639	0.09
1000 grain weight (9)	Normal	-0.116	-0.015	0.014	0.071	-0.015	-0.02	-0.04	0.009	-0.333		0.625	0.186
	Stress	0.091	0.003	0.011	0.119	-0.608	-0.035	-0.002	-0.039	-0.097		0.243	0.23
Harvest index (10)	Normal	1.579	-0.036	0.047	0.112	-0.031	-0.031	-0.072	0.013	-0.935	-0.046		0.605
	Stress	0.792	0.006	-0.005	0.119	-0.078	-0.029	-0.001	-0.009	-0.422	0.028		0.405

terms of number of grains per spike and plant height for selection of genotype for drought stress condition, because this analysis was simple, repeatable and economic.

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