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Studying the morphological traits of winter barley varieties and lines in Ardabil using multivariate statistical methods

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Abstract

We conducted an experiment at Agricultural Research and Natural Resources station located in east 10 km from Ardabil (Aralloo region) in 2012-2013 to study the morphological traits of few winter barley varieties and lines. In this research 8 promising varieties and lines of barley were culture in a complete random block design with three replications, and the following traits were measured; number of whole tiller, number of fertile, plant height, awn length, peduncle length, spike, spikelet number spike, grain number per spike, 1000 grain weight, grain weight per spike, grain weight per whole plant, straw weight, grain at experimental plot (6 square meters to gram), harvest index, day number to 50% heading and Date of maturity, the result from variance analysis of measured traits showed that there was a significant difference in 5% and 1% probable level between studied lines except for whole tiller number, fertile tiller number, grain weight per spike, grain weight per whole plant, straw weight, whole plant weight and yield in other traits. This comes from high genetic diversity between studied lines. The modified coefficient of determination was 0.86 in fitted model showing 86% justification of changes within seed. Yield by indicated variables. The first included variable in to the model was harvest index, the second variable day to physiological maturity and finally determination coefficient of model was 0.86 with inclusion of spike length. The maximum regression coefficient was related to harvest index and regression coefficient of harvest index was positive and regression coefficient day to physiological maturity and spike length was negative. So harvest index can be considered as effective trait on grain yield. The results from causation analysis showed that harvest index has a higher and direct effect (0.613) on grain yield and the positive correlation coefficient 0.54 between harvest index and grain yield was mainly relation to the direct effect of harvest index and the indirect effects have less important role on yield. Also day to physiological maturity and spike length have negative and direct effect.

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Introduction

Due to increasing population growth in the world scientists and scholars have predicted that world population will be 10 milliard people by 2030, now the question raises that what should do to supply food for such as a population and what kind of solutions should be considered (Abdemishani and Nejat Booshahri,1996). According to the most recent statistics from Grocery and Agricultural United Nations, world population will be more than7 milliard people by 2013. Regarding present world population coming 40 years, food production should be 3 times to supply food for 9 milliard people (FAO, 2013).

The population is increasingly grown in developing countries however farmlands extension is decreasing and events such as draught, disease and soil fertility reduction is decreasing productions. Considering the importance of the issue, it is really important to get ways to increase crops yield. Evidence shows that during 30 to 40 last years, at least 50% of product increasing of some of main crop productions have been gotten by breeding methods. (Farsi and Baqeri, 1997). Among crops, barley seed is the richest source for efficient food supplies on human healthy. Iranian food contains high starch and plant fibers due to abundance and relative cheapness of vegetables which can explode and promote population healthy improvement if protein and starch decreases. This is possible if the related organizations product more and cheaper meat and barley seed can critically underlie nutrition in industrial stock raising (Anonymous. 2005).

The most basically way to increase economical yield of barley cultivation is using of compatible, resistant and high yield varieties proportional to the region. In this course it is worthy to note that study and measure of compatibility of varieties in different conditions and environments is important in plants breading (Rahimian *et al*, 1993). Ardabil province has located in both cold (Ardabil plain in south of province and Caspian beach climate (Moghan plain in north of province) considering crops and Makooee blue barley and Bahman are cultured in the city. A few of barley lines and varieties are new in research and no study and experiment has conducted on them in such conditions in Ardabil.

In order to increase yield in breading methods we can use topics on quantitative genetics and understand yield components that are important in its improvement (Ehdaei, 1996 and Farshadfar, 1998). Before that we should compute yield relation with its components, in the other hands, the correlation between yield trait and its related traits and components and due to effective factors in variation that is genotype and environment yield components effect should be determined (Falcoer, 1999 and Fashadfar, 1999). Understanding the genetic characteristics of train, their relation and how traits affect each other to gain desired goals in breeding are important. We can determine the best breeding method and the most effective traits through understanding these relations (Allah Gholipour and Salehi, 2004). In this way, the correlation coefficients between traits are separated into components that measure their direct and indirect effects. I studies about yield-related traits we use causality method to study traits effects on yield and the relationship between traits. By using this method we can analyze the correlation between yield and its components and determine its direct and indirect effects (Farshadfar, 1998 and 1999). Leilah and AL-khateebs (2005) use 7 different statistical methods in their research such as causality analyze method to study the relationship between yield and its components in draught stress. Hosseinzadeh *et al* (2009) in a study based on stepwise regression seed yield, as a dependent variable and biologic yield Shoot weight, leaf area in the canopy closure, plant height and days number to 50% flowering were included into the model as independent variables. Determination coefficient model was R2 = 1. Biological yield had direct considerable effect on the increasing of grain yield. The negative direct effect of stem weight and plant height on grain yield was offset by the positive

indirect effect via biological yield and made an increase in correlation of these traits with grain yield. On the contrary, the positive direct effect of day number to 50% flowering on grain yield offset by negative indirect effects via biological yield and made a decrease in the correlation of this with grain yield, so the most important traits as selection to improve yield included biological yield. Jabbari *et al* (2012) results from stepwise multiple regression showed that traits such as seed number per spike, spike length, peduncle length and awn length played the most significant role in justifying yield changes in both aqueous conditions and stress. The results from path analysis emphasized on the main roles of direct effects on grain yield and the importance of seed number per spike. Plant height, duration of reproductive growth and flag leaf sheath length played considerable role in seed yield variability by affecting mentioned components. These traits along with other determined traits can be introduced as the best selection criterion of genotypes with high yield.

This research aims at introducing high yield barley lines in environmental conditions of Ardabil and determining main morphological traits in grain yield especially in coldness of Ardabil.

Materials and Methods

Experiment location

This experiment was conducted at Agricultural research and Natural Resources station in Ardabil (with 1350 meters height, latitude 38 degrees and 15 minutes north and longitudinal 48 degrees and 15 minutes east and annually mean rain 280-300 mm) 10 km east from Ardabil (Aralloo region) in 2012-2013 crop year. The physicochemical results from tested from soil sample are given in Table 1. And the regional climate specifications of the experiment are given in Table 2.

Table 1. The physicochemical results from tested farm soil sample.

Tissue	Percent Sand	Percent Silt	percent Clay	Percent Lime	Percent saturation	pH	Salinity (ds/m)
Clay loam	31	30	39	5	53	7.76	2.04
Percent organic carbon	N (p.p.m)	Resorbable phosphorus (p.p.m)	Potassium Resorbable (p.p.m)	Zn (p.p.m)	Fe (p.p.m)	Cu (p.p.m)	Ma (p.p.m)
0.858	0.08	2.2	594	2.32	2.52	8.56	4.27

Table 2. Atmosphere specifications of Experiment location in Ardabil in 2012-2013 crop year.

Parameter	Local	Mehr	Aban	Azar	Dei	Bahman	Esfand
Rainfall	Ardabil	8.3	25.6	26.7	11	28.5	24.1
Average minimum temperatures	Ardabil	7.3	4.8	0.3	-2.4	1	1.1
Average maximum temperature	Ardabil	21.9	16.9	8.9	6	11.1	11.9
Average daily temperature	Ardabil	14.6	10.9	4.6	1.8	6.1	6.5
Average minimum humidity	Ardabil	42	48	60	41	45	43
Average maximum moisture	Ardabil	97	94	94	82	84	84
Average humidity	Ardabil	70	71	77	62	65	64
Total sunshine hours	Ardabil	244	168.4	120.1	173	170.5	154.8

Source: Meteorological Ardabil Province

Continued Table 2

Parameter	Local	Farvardin	Ordibehesht	Khordad	Tir	Mordad	Shahrivar
Rainfall	Ardabil	10.7	48.1	57.3	0.7	16	6.4
Average minimum temperatures	Ardabil	2.4	4.2	9.3	11.3	12.4	11.5
Average maximum temperature	Ardabil	16.9	18.2	22.9	23.8	22.3	25.2
Average daily temperature	Ardabil	9.7	11.2	1.16	17.6	17.4	18.4
Average minimum humidity	Ardabil	40	45	44	43	52	43
Average maximum moisture	Ardabil	87	86	89	85	91	92
Average humidity	Ardabil	64	66	67	64	72	68
Total sunshine hours	Ardabil	214.5	247	280.1	346.9	253.9	275

Source: Meteorological Ardabil Province

Experiment plot

In this research 8 promising varieties and lines of barley (table 3) were cultured in a complete block design with three replications. The irrigation was traditionally done 4 times until physiological maturity. Each line and variety were considered in 6 rows plots and each plot was 7 meters and the space between lines was 20 cm. Grain density was 350 seeds per square water. Two- four-D was used to control grass and broad leaf weeds during cultivation. Fertilizing of cultured land was done based on fertilizer advice on soil test tillage and disk. The following traits were measured in this research; total number of tiller, fertile tiller number, plant height, awn length, Peduncle length, spike length, spikelet number per spike, grain number per spike, 1000 grain weight, grain weight per spike, grain weight per whole plant, straw weight, grain yield per experimental plot (6 meter square to gram) harvest index, day to 50% heading and day to physiological maturity.

Table 3. Names the studied genotypes.

Number	Genotype and Line	Number	Genotype and Line
1	Bahman	5	Bereke-54/Alanda
2	ALGER/(CI10117/CHOYO.. //1-BC-80467	6	Debut/5/B/A/4/A/3/Jotun/5*Hudson //Ri/VA66-42-45/6/K-273/Ste
3	ALGER/(CI10117/CHOYO..//Zarjow/U.N.K	7	L.1242/ZARJOW//LB.Iran/Una8271 /Gloria"S"/Com"S"
4	Ste/L.640//Hml-02/Arabi Abiad*2/ 3/1-BC-80593	8	Legia/3/Torsh/9Cr.279-07//Bgs

Statistical analysis

Variance analysis was used in a completed random block design to study the difference among varieties. Duncan trial was used in 5% probable level to compare the mean of interactions and simple effects. Computer soft wares such as SPSS 18 and MSTATIC

were used to statistically calculations and Excel software was used to draw tabled and graphs.

Results and Discussion

The results from variance analysis of measured traits are given in Table 4. As it can be observed there is a significant difference in 1% And 5% probable level between studied lines except for total number of tiller, fertile tiller number, given weight per spike, grain weight per total plant, straw weight, total weight and yield in other traits. This comes from high genetic diversity among studied lines.

Day to 50% heading

The range of day number to 50% heading varied from 117 days (line 3) to 126.33 day (control variety Bahman) among studied varieties. Line 3 was the earliest maturity and control variety (Bahman) with lines 2, 5, 6 and was the longest day number to 50% heading among genotypes (table 5).

Table 4. Variance analysis of studied traits in a complete random block design.

Source	df	Mean of Squares								
		Days to 50% heading	Date of maturity	The total number of tillers	Number of fertile tillers	Awn length	Peduncle length	Spike length	Plant height	The number of spikelet's per spike
Replication	2	0.875	55.292**	0.012	0.095	0.282	14.619	0.068	344.162**	1.713
Genotypes	7	29.905**	25.214**	0.88	0.151	4.093**	22.808*	1.051**	242.106**	7.696*
Error	14	4.494	0.482	0.65	0.312	0.242	7.249	0.162	35.186	2.702
C. V %		1.73	0.38	24.88	21.07	4.82	9.86	10.29	7.04	13.75

* and ** Significantly at p < 0.05 and < 0.01, respectively.

Source	df	Mean of Squares							
		Number of grains per spike	1000 grain weight	The main spike grain weight	Seed weight per plant	Straw weight	Total plant weight	Harvest Index	Yield
Replication	2	7.607	19.314	0.071	0.0027	1.032	1.162	34.167	334429.2
Genotypes	7	93.351**	71.531**	0.085	0.809	0.642	0.914	102.708**	409723.81
Error	14	20.66	9.995	0.057	1.186	1.033	4.204	13.119	253857.738
C. V %		14.97	7.74	14.26	22.25	26.02	24.25	7.38	11.35

* and ** Significantly at p < 0.05 and < 0.01, respectively.

Table 5. Comparing studied average lines of barley in measured traits by Duncan test.

No. Genotypes	Traits									
	Date of maturity		Days to 50% heading		Peduncle length		Awn length		Spike length	
Bahman	126.33	a	179.33	cd	8.6	d	24.57	b	3.67	bc
2	123.33	ab	180.33	bc	10.27	c	27.98	ab	4.29	b
3	117	d	178.33	de	11.27	b	32.16	a	5.06	a
4	118	cd	178	e	9.93	c	24.45	b	4.13	b
5	122.67	ab	181	b	12.4	a	27.33	ab	3.55	bc
6	126.67	ab	185	a	9.47	c	28.49	ab	3.29	c
7	124	ab	179.67	c	10	c	29.03	ab	3.31	c
8	121	bc	185.67	a	9.6	c	27.24	b	4.01	bc

means values with common letters in each column have no significant difference based on Duncan Test, at 5% probability level

No. Genotypes	Traits									
	Plant height		The number of spikelet's per spike		Number of grains per spike		1000 grain weight		Harvest Index	
Bahman	72.27	c	14.02	a	38.83	a	34.05	d	56	a
2	81.20	bc	13.01	ab	30.11	bcd	44.48	a	55.33	a
3	102.53	a	13.67	ab	35.92	ab	37.88	cd	49.67	ab
4	81.07	bc	1051	bc	24.6	cd	45.89	a	41	c
5	85.4	b	9.38	c	21.54	d	47.17	a	40.33	c
6	85.93	b	12.04	abc	32.2	abc	43.03	ab	48	b
7	88.2	b	10.98	abc	29.93	bcd	36.52	cd	52	ab
8	77.23	bc	12.04	abc	29.68	bcd	37.70	d	50	ab

means values with common letters in each column have no significant difference based on Duncan Test, at 5% probability level

Date of maturity

the range of Date of maturity varied from 178 days (line 3) to 185.67 days (line 8) among studied varieties and lines and this shows that line 3 was the most early maturing line 8 with line 6 were the latest maturity among measured lines. (Table 5)

Awn length

Line 5 had the longest awn with 12.4 cm average and was categorized in superior statistical group and control variety (Bahman) had the shortest awn length with 8.6 cm average among studied varieties and lines and were categorized in class d(Table 5).

Peduncle length

Line 3 had the longest peduncle with 32.16 cm average with lines 2, 5, 6, and 7 were placed in superior statistical group and line 4 and control variety (Bahman) had the shortest peduncle length with 24.45 and 24.52 cm average, respectively among studied lines and varieties and were categorized in class b (Table 5).

Spike length

Spike length is one of the main yield components in granule crops and it is better to select genotypes with maximum spike length to increase grain yield per unit area. Line 3 had the highest spike length with 5.06 cm average and was categorized in superior statistical group and lines 6 and 7 devoted the least spike length with 3.29 and 3.31 respectively to themselves among studied lines and varieties and were categorized in class c with lines 5 and 8 and control variety (Bahman) (Table 5).

Plant height

The significance difference of studied lines in plant height showed that there is a genetic diversity between lines and can be used in next studies corresponding to the findings of Khajavi (2011), Mirzaei (2012) and Azizi (2013). In conditions of aquaculture of barley usually lines and varieties of around 90-100 cm height are selected because such varieties aren't involved in plant lodging in aquaculture. The range of plant height among studied varieties and lines varied from 72.27 cm (control variety) to 102.53 cm (line 3). Line 3 devoted the highest plant height to itself with 102.53 cm average and was categorized in class A and control variety (Bahman) devoted the least plant height with 72.27 cm average. To itself among studied lines and was categorized in class c with lines2, 4 and 8 (Table 5).

Spikelet number per spike

The range of spikelet number per spike varied from 9.38 (line 5) to 14.02 (control) among studied varieties and lines. Control variety (Bahman) devoted the highest spikelet number per spike to itself with 14.02 average number and was categorized in the same class of lines 2, 3, 6, 7 and line 5 devoted the least spikelet number per spike to itself with 9.38 average number among studied lines and varieties and was categorized in class c with lines 4, 6, 7 and 8 (Table 5).

Seed number per spike

Seed number per spike in draught stress and in average cases of seed number has a contribution of total number of spike in yield, that's why seed number per spike is suggested as the selection criterion of dry land varieties (Asana, 1962).

Range of seed number per spike varied from 21.54 (line 5) to 38.83 (control variety) among studied varieties and lines. Control variety (Bahman) devoted the highest seed number per spike with 38.83 average number and was categorized in the same class with lines 3, 6, 7 and 8, and line 5 devoted the least seed number per spike with 21.54 average number among studied lines and varieties and were placed in class d with lines 2 and 4 (Table 5).

1000 seeds weight

1000 seeds weight is one of main criteria of quality of grain yield. High 1000 grains weight increases germination and growing percent and more plants are kept with spike until harvesting which is effective on yield. Range of 1000 seeds weight varied from 34.05 gr (control variety) to 47.17 gr (line 5) among studied lines. Lines 5, 4 and 2 devoted the highest 1000 seeds weight with 47.17, 45.89 and 44.48 averages respectively. And were placed in the same class with line 6 and control variety (Bahman) and line 8 devoted the least 1000 seeds weight to itself with 45.07 and 37.7 gram average respectively among studied lines and were placed in class d (Table 5).

Harvest Index

Harvest index is one of main parameters to predict grain yield (Arab Ameri *et al*, 2011). Line 2 and control variety (Bahman) devoted the least harvest index to themselves with 55.33 ad 56% averages respectively and were categorized in the same class with lines 3, 7 and 8 and lines 4 and 5 devoted the highest harvest index to themselves with 41 and 40.33% averages respectively among studied lines and were categorized in class c (Table 5).

Regression analysis

In order to determine the contribution effects of traits in determining yield descending regression method was used. First independence of experimental errors was tested using telescope- Watson trail and showed that errors are independent. Also statistical of variance inflation factor less than 10 showed that

there is no multiline. Multiple regression analysis was performed for grain yield as a dependant variable for all traits in a descending method. In this analysis the variables of significant effects remained in equation were: harvest index, Date of maturity and spike length (Table 6).

Grain yield = 13012.542+38.78(harvest index) ** -46.175 (Date of maturity)* - 542.829 (Spike length)**

Table 6. Regression Analysis Method Descending.

S.O.V	df	SS	MS	F
Regression	3	880630	293543.3226	15.574*
Residual	4	75392.185	18848.046	
Total	7	956022.2		

R2=0.86
* and Significantly at $p < 0.05$
Independent variable: harvest index, days to maturity, spike length
dependent variable: Grain yield

Regression line equation

Grain yield = 13012.542+38.78(harvest index) ** -46.175 (Date of maturity)* - 542.829 (Spike length)**

Table 6 Regression analysis in a descending method the modified determination coefficient in a fitted model was 0.86 showing 86% justification of change in grain yield by indicated variables. In Table 7 the values related to regression coefficients and inclusion order of variable into mode are given. The first included variable into the model was harvest index; the second variable was Date of maturity and at last the model determination coefficient was 0.86 by including spike length. The higher regression coefficient was related to harvest index and related to harvest index related regression coefficient positive and spike length was negative. So harvest index can be introduced as an effective trait on grain yield.

Table 7. Summary of descending regression analysis.

Variable	b	Standardized regression coefficient	Prob.	VIF
α	13012.542	-	0.025	-
Harvest index	38.78	0.614	0.012	1.009
Days to maturity	-46.175	-0.362	0.078	1.195
Spike length	-542.829	-0.869	0.005	1.201

Path Analysis

Analysis of causality is a very important in determining the relationship between the main characters and economic yield. Calculation of correlation coefficients don't determine the nature of the relationship between traits but it is possible to identify direct and indirect effects of effective traits yield using causality analysis (path analysis), that's why breeding specialists use path analysis as an effective means of determining the importance of traits effects on yield. In order to find causal relationships between dependant variables of grain yield in one hand and variables of significant effect on economic yield we used path analysis. The results from path analysis (Table 8) showed that harvest index has a highly and direct effect on grain yield and the positive correlation coefficient 0.54 between harvest index and grain yield was mainly related to the direct effect of harvest index and the indirect effect have less important effect on yield. Also days to maturity and spike length had a direct and negative effect. The direct effect of spike length on yield was high and negative (-0.87). The remained effect (0.28) indicates that in addition to above variables, there are other factors justify changes of grain yield.

Nematullahi (2012) studying the comparison of promising barley lines in yield and agronomical traits in Ardabil reported that total plant weight had a direct and high (0.598) effect on grain weight per spike and the positive correlation coefficient (0.779**) between total plant weight and grain weight per spike was mainly related to the direct effect of

total plant weight per stem. The direct effect of fertile tiller on grain weight per spike was negative and high (-0.394) also the indirect effect of grain number per spike through total plant weight was higher than indirect effect of fertile tiller through total plant weight. Mirzaei (2012) reported that fertile tiller number had the highest direct effect (0.592) on grain yield. The positive correlation coefficient (0.73**) between fertile tiller number and grain yield was mainly related to direct effect of fertile tiller number per main stem and the indirect effects through this trait are effective on grain yield as well. Straw weight had the highest indirect effect through fertile tiller number (0.246) on grain yield. In 2013 Azizi by studying 20 barley lines reported that the highest regression coefficient was relation to 1000 grain weight and regression coefficient was related to 1000 grain weight and spike length was positive and the regression coefficient of plant height was negative. So 1000 grain weight and spike length can be offered as the effective traits on grain yield. Path analysis of remained traits in regression model showed that based on this analysis 1000 grain weight had the direct and the highest (0.624) effect on the grain yield and after that spike length average had a direct and positive effect on grain yield (0.385) and plant height had a direct and negative effect on grain yield.

Table 8. The correlation coefficients analysis on direct and indirect effects for grain yield.

Traits	Direct effect	Indirect effect through			Simple correlation with grain yield
		harvest index	days to maturity	spike length	
harvest index	0.613	-	-0.01	-0.065	0.54
days to maturity	-0.363	0.015	-	0.347	0.001
spike length	-0.87	0.045	0.144	-	-0.68
Residual = 0.28					

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