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Reviewing Changes of Yield Relationship with Yield Components of Promising Genotypes of Rainfed Barley by Path Analysis

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ABSTRACT: An experiment was conducted in a randomized complete block design with four replications on 15 promising barley lines in rain-fed agricultural research site of KhorasanShomali within 20 km from Shirvan in 2011-2012. The aim was studying the correlation of grain yield with yield components and determining the contribution of yield components and estimating the direct and indirect effects of yield components on grain yield. Traits including days to heading, number of days to maturity, grain height, panicle length, number of panicles per square meter , number of grains per panicle, biological yield, grain weight, harvest index and grain yield. Data analysis showed a significant difference between lines in term of all the traits. The traits such ascorrelation and path analysis were also studied. Path analysis**,** numbers of panicle per square meter, number of grains per panicle and grain weight had the most direct effect on grain yield, respectively, these traits could be used as selection criterion in barley breeding programs and producing high-yielding varieties. Number of panicle per square meter had the most indirect positive effect on grain yield through number of grains per panicle, panicle length and biological yield.Correlation coefficients showed that there was a significant negative correlation with the probability of (α= 0.01) between the traits of grain weight with grain number and there was a positive and significant relationship between numbers of panicle per square meter and number of grains per panicle. Furthermore, there was a positive and non-significant correlation between grain weight and yield and there was a positive and significant correlation between number of grains per panicle and numbers of panicle per square meter and yield with the probability of (α= 0.01). The comparison of means of grain yield showed that the grain had the highest yield between the lines 3, 6, and 4 in terms of grain yield.Total average of grain yield was 1785 kg per hectare and the coefficient of the experiment variations was 4.49%.

***Keywords*:** Direct effects, path analysis, barley, grain yield, traits correlation

INTRODUCTION

Barley (Hordioumvulgare), a member of grass family (Graminae or Poaceae), it is an annual plant and self-pollinatedand one of the oldest and most important cereals in Iran, which is grown in a level equivalent to 15 million hectares (irrigated – rain-fed), more than 60 percent of the area is grown as rain-fed.Average yield of rain-fed barley has been reported to be 700 to 900 kilograms per hectare in Iran (FAO, 2005). The rainfall is limited in Iran due to locating in an arid and semi-arid area but we can prevent from production losses in the years of low rainfall

by planning and using facilities (Mohammadi, 2001). Many phenomena and factors are uncontrollable or non-adjustment despite the fact that they influence rain-fed agriculture. Direct relationship of yield in the production of rain-fed agriculture with the natural conditions and year to year changes of rainfall and its distribution as well as fluctuations in temperature and lack of rainfall in part of crop year and so on cause the high risk factor and low reliability coefficient and low degree of stability in production in rain-fed agriculture.Therefore, breeders consider many tools and techniques that reduce risk and provide yield stability of rain-fed products (Jahansooz and Moghimi, 2012).

Increasing the grain yield per unit area is one of the interesting topics to professionals of plant breeding in fine-grained cereals. Therefore, it is necessary to determine the reasons for yield variability. Better understanding of the yield constraints requires analysis of phonological events. Grain yield is the process of increasing dry weight of grain per unit area per unit time during grain formation **(**Deay Volvo, 1959).(Puri et al., 1982) stated that the grain yield in wheat and barley resulting from the cumulative effect of its components. (Jones et al., 1978) stated that the main components of yield in cereal are number of grains per panicle, number of panicles per square meter and grain weight. All traits including maturity -related features such as the number of days to heading (vegetative growth) and duration of grain filling have an important contribution to the grain yield (Bhatt , 2005).

(Mosber ,1994) reported, in a study conducted on the correlation between yield and its components in some morphological traits of barley through path analysis, that the trait of the number of grain in panicle had the most direct positive effects on grain yield. (Gootba ,1984) also stated that the trait of grain weight in barley had the little direct effect on grain yield. (Mutants and Sami ,1973) also showed that the highest correlation with yield was related to grain number in panicle and grain weight.

Asadullahzade et al (2010), in a study conducted on wheat genotypes, found that there was a very good and positive relation between biological yield and grain yield.

(Ekman ,1981) reported that increased harvest index in barley can increase the grain yield which corresponded with the result stated by (Ghanbari, 1996 and Bahadori, 1998), that is, one good way to increase the yield is the increased harvest index with reduced straw yield or increased grain yield and the stability of biological performance.

Although there is a positive relationship between yield and the number of components,the negative correlation between some of the components cannot make a useful choice for all yield components as a factor in increasing the yieldof fine-grained cereal (Danyard and Gothenburg, 1976).Increase in one component usually leads to cut down on some of the other components (Puri et al., 1982 and Rasmussen, 1987).Determining the correlation between different traits, particularly grain yield and its components and also determining causal relationships provide the breeders with the opportunity to select the most appropriate combination of components that will lead to greater yield (Moradi et al., 2010).Selecting based on simple correlations cannot provide quite favorable results.It is therefore essential to determine the direct and indirect effects of traits affecting grain yield (Dray volvo, 1959; dofing and Knight, 1972), sopath analysis is of particular importance (Rasmussen , 1987),path analysis (path coefficient analysis) which has been proposed by Wright (Wright , 1921) is a method in whichrelationships between traits and their effects were determined on yield. Here,the correlation coefficient between two traits is divided into components which measure the direct and indirect effects (Allah Gholipour, 1997). The purpose of this experiment was to determine the most appropriate variety in term of qualitative traits and grain yield as well as finding the most appropriate and effective physiological yield-related traits in order to focus on eugenic activities of that trait and increase yield.

MATERIALS AND METHODS

The study conducted during the crop year of 2011-2012 in the field of rain-fed agricultural research stations in Shirvan. This area is located within the latitude of 19/37 ^{0} north and longitude of 07 / 58 ^{0} west and its height from sea level is 1131 meter and the average thirteen years rainfall of which is 267 mm.In this study, 15 genotypes of barley (Table 1) were planted in a randomized complete block design with four replications.Area of each experimental unit was 7.5 meter including 6 lines of 5 meter with line spacing of 25 centimeter and grain level was 350-400 per square meter. Experiments measured traits were: 1-number of days to heading, 2-days to maturity, 3–height, 4–panicle length, 5-number of panicles per square meter, 6-number of grain in panicle, 7-grain weight, 8-peduncle length, 9-grain yield, 10- biological yield, and 11-harvest index.

plant height, panicle length, peduncle length, and maturity time were measured and the traits of grain weight, number of grains per panicle, grain yield and biological yield were sampled after harvesting.

All data were analyzed using MSTAT-C software and simple correlation between traits was accounted and path analysis was also analyzed by PATH software.

Table 1. Characteristics of 15 genotypes of rain-fed barley

Variety / Line
Abidar
Yea 168.4/Yea 605.5 Yea206-4A-3
Sahand
Sahand/C-25041 IRB-04-059-OMh-Omh-Omh-Omh-1Mh
Sahand/C-25041 IRB-04-059-OMh-Omh-Omh-Omh-2Mh
Sahand/C-25041 IRB-04-059-OMh-Omh-Omh-Omh-5Mh
ARM-ICB-123199/3/Zarjau/80-5151//Skorohod ICB04-1466-0AP-0Mh-Omh-Omh-1Mh
ARM-ICB-123199/3/Zarjau/80-5151//Skorohod ICB04-1466-0AP-0Mh-Omh-Omh-3Mh
ARM-ICB-123199/3/Zarjau/80-5151//Skorohod ICB04-1466-0AP-0Mh-Omh-Omh-4Mh
ARM-ICB-123199/3/Zarjau/80-5151//Skorohod ICB04-1466-0AP-0Mh-Omh-Omh-5Mh
Unknown-F6-88-8
Unknown-F6-88-11
Unknown-F6-88-16
Alpha/Gumhuriyet//Sonate/3/Sararood ICB02-1570-4AP-0AP
Victoria/Tirchmir-43 ICBH96-0510-0AP-16AP-14AP-0AP

RESULTS AND DISCUSSION

The result of variance analysis of data-related traits listed in table 2 and showed that there was a significant relation of the probability of (α=0.01) between all genotypes in termsof studied traits.Thus, there is the possibility of selection for traits due to the differences. The coefficient of variation was also low in the studied traits indicated that the experiment has been carried out with sufficient accuracy.Lines 3, 6, and 4, respectively, had the highest yield with an average yield of 2188, 2201 and 2133 kg per hectare (Table 2).Lines 2 and 3 had the highest harvest index in term of the number of panicle per square meter, line 4 in term of the number of grains per panicle, lines 6 and 7 in term of grain weight, line 3 in term of panicle length, line 6 in terms of biological yield and lines 3and5 in term of harvest index.

There was a significant positive correlation between grain yield and number of panicles per square meter and number of grain in panicle and biological yield according to the table of correlations between traits, and the correlation coefficient were r=0.645, r=0.838, and r=0.813, respectively (Table 4).It can be concluded that the high yield of genotypes 3, 6 and 4, is related to the high correlation of traits such as the number of panicle per square meter, the number of grain in panicle, and biological yield with grain yield due to the high positive correlation of grain yield with the traits. Dora Rabiti (1998) reported a significant positive correlation between grain yield, number of grains per panicle, panicle length and number of panicle per square meter. (Furthermore,Monreal et al.,1997) reported a positive non-significant correlation between grain yield and grain weight in wheat which was somewhat consistent with the results of this experiment. Traits table correlation showed that there was a non-significant positive correlation between grain height and yield which was quite consistent with the result of the experiment conducted by (Drikvaind et al ., 2011) to investigate the correlation of path analysis traits on different variety of barley.

In this study, the lowest yield was related to lines 15, 1, 10 with an average yield of 1182, 1314 and 1500 kg ha, respectively (Table 2).These lines have the lowest biological yield, the minimum number of panicles per square meter and also the minimum number of grains per panicle than the other lines.

In this experiment, the correlation of grain yield with the traits of numbers of days to heading, days to maturity, plant height and grain weight were non-significant and negative.Positive correlation between grain yield and plant height was probably due to an increase in panicle length, number of grains per panicle and biological yield (Donaldson et al 2001, KashefKhaliq 2004) because the traits have a positive correlation with the bush height.

According to the results of (Kamran Valizade ,2003) the grain yield increase with increased biological yield in barley. Furthermore, line 15 had the lowest biological yield due to the limitation of increase in the harvest index as well as the lowest grain yield was related to lines 15. Line 5 had the highest harvest index (table 3).

Significant correlation of plant height, number of panicles per square meter, number of grains per panicle and panicle length with biological yield represented that biological yield decreased if these traits had declined and consequently the harvest index would increase.Correlation of biological yield and plant height stated that leaf area index increased if the height had increased, had used the maximum of available resources, and ultimately lead to increase in dry weight (biological function).

The lowest harvest index was 26.44 and 38.67 which was related to lines 6 and 13, respectively (Table 3). And line 6 accounted for the highest amount of grain weight than other lines. Because it had lower number of grains per panicle and also lower number of panicle per square meter and since there was a negative and highly significant relationship between the number of grains per panicle and number of panicles per square meter and grain weight, the grain weight increased. The correlation between harvest index and grain weight was non -significant and negative, which was consistent with the results of (HelaliSultanabadi and et al., 2006).

The results of path analysis table showed that all the studied traits influenced the yield about 94%.And the trait number of panicles per square meter had the highest direct effect on grain yield which was consistent with the results of (JafariHaghighi ,2009); numbers of grains per panicle and grain weight were followed by. Furthermore, number of panicles per square meter had the most indirect positive effect on grain yield through number of grains per panicle, panicle length and biological yield.These results indicated that the direct effect of number of panicles per square meter on increased grain yield was simultaneous with its indirect effect through number of grains per panicle and panicle length.These results seemed reasonable due to the positive correlation of number of panicles per square meter with number of grains per panicle and panicle length. The direct effect of number of grains per panicle on yield was positive and relatively high as well as its indirect effect through number of panicles per square meter was positive and relatively high. Furthermore, the indirect effect of number of panicles per square meter through grain wheat was negative and high. The results were consistent with the results of the experiments of (Neyestani et al ., 2005) investigated path analysis at different varieties of barley.

CONCLUSION

Path analysis of yield components showed that the numbers of panicles per square meter, number of grains per panicle and grain weight are the most effective traits in increasing grain yield as well as changes in yield biological. Genotype No. 3 is introduced as the top line due to high number of grains per panicle and high number of panicles per square meter and high yield than other lines.

Table 2 . Analysis of variance of 15 barley genotypes

changes resources	degree of freedom	day to heading	day to maturity	plant height	panicle per squqre meter	grain per panicle
replication	3	1.498ns	4.861ns	0.46ns	6.328ns	0.234ns
genotype	14	51.702**	8.088**	59.367**	3334.659**	16.702**
error	42	1.429	1.742	0.469	11.863	0.504
changes coefficient (%)		0.72	0.68	1.15	1.39	3.74

* and ** are the significance of 1% and 5%

Table 2 . (continued) .Analysis of variance of 15 barley genotypes

changes resources	degree of freedom	Grain wheight	Panicle lenght	Pedanclelenght	Grain yield	Biological yield	Harvest index
replication	3	2.186ns	2516ns	0.18ns	3667.24ns	688551.41ns	0.771ns
genotype	14	30.07**	21.02**	0.094**	402315.04**	6688370.03**	**45.063
error	42	0.302	0.665	0.046	6270.95	303811.25	1.135
changes coefficient (%)		1.46	4.38	22.45	4.49	10.21	3.26

* and ** are the significance of 1% and 5%

Table 3. Comparison of means of 15 genotypes of rain-fed barley

genotyp	degree of freedom	day to maturity	day to heading	panicle per squqre meter	grain per ppanicle	Grain wheight
1	162.0 e	190.8 e	61.00 de	219.8 g	19.01 ef	35.95 g
2	165.0 d	193.8 abc	62.50 b	294.5 a	16.73 g	36.10 g
3	162.0 e	191.5 de	50.95 h	293.8 a	21.33 a	37.10 f
4	165.8 d	193.3 bcd	60.90 de	281.8 b	21.24 ab	35.65 g
5	170.0 b	195.0 ab	58.60 g	254.0 c	19.45 def	38.05 e
6	172.0 a	195.0 ab	51.70 h	242.3 de	21.02 abc	43.20 a
7	162.0 e	192.5 cde	64.90 a	241.0 de	20.05 cd	42.00 b
8	165.5 d	194.3 abc	58.50 g	226.5 b	20.05 cd	36.90 f
9	165.5 d	194.3 abc	59.30 fg	274.5 b	20.24 bcd	32.80 i
10	170.0 b	195.0 ab	60.05 ef	200.8 h	16.35 g	40.04 c
11	171.5 ab	195.5 ab	60.17 def	250.0 cd	16.10 g	34.50 h
12	170.0 b	195.0 ab	64.00 a	237.8 ef	19.90 de	39.15 d
13	171.5 ab	195.0 ab	61.13 cd	243.0 cde	20.00 de	37.08 f
14	168.0 c	195.0 ab	59.32 fg	238.8 de	18.80 f	36.03 g
15	166.5 cd	194.5 ab	62.03 bc	221.3 g	14.81 h	38.65 de

Table 3 (continued)- comparison of means of 15 genotypes of rain-fed barley

genotyp	Panicle lenght	Pedanclelenght	Grain yield	Biologyic yield	Harvest index
1	18.25 cd	0.9750 abc	1500 h	5237 efg	28.66 f
2	18.25 cd	1.025 abc	1773 ef	5056 fg	35.08 bc
3	19.75 a	1.250 a	2188 a	6049 bcd	36.36 ab
4	19.00 abcd	0.7500 cd	2133 ab	6418 bc	33.27 d
5	18.25 cd	1.075 ab	1879 de	5085 fg	36.95 a
6	18.75 abcd	0.8750 bcd	2201 a	8320 a	26.44 g
7	18.00 d	0.9500 abc	2030 bc	5793 cdef	35.06 bc
8	18.50 bcd	0.900 bcd	1675 fg	5900 cde	28.40 f
9	18.88 abcd	0.850 bcd	1822 de	5404 defg	33.74 cd
10	19.52 ab	0.975 abc	1314 i	3617 ij	36.33 ab
11	18.63 abcd	0.625 d	1389 hi	4230 hi	32.85 d
12	18.50 bcd	0.975 abc	1851 de	5305 defg	34.90 bc
13	19.38 abc	0.875 bcd	1922 cd	6703 b	28.67 f
14	19.00 abcd	1.025 abc	1617 g	4998 gh	32.42 d
15	16.75 e	1.150 ab	1182 j	2878 j	30.42 e

Table 4. Correlation coefficient for 15 genotypes of rain-fed barley

	day to heading	day to maturity	plant height	panicle per squqre meter	grain per panicle	Grain wheight	Panicle lenght	Pedanclelenght	Harvest index	Biological yield	Grain yield
grain per panicle	1										
grain per panicle	0.685**	1									
grain per panicle	- 0.008	- 0.008	1								
grain per panicle	- 0.254	- 0.187	0.177	1							
grain per panicle	- 0.065	- 0.136	0.218	0.329*	1						
Pedanclelenght	0.166	0.063	- 0.59**	- 0.395**	- 0.831**	1					
Pedanclelenght	0.117	- 0.105	0.062	0.234	0.289	- 0.089	1				
Pedanclelenght	- 0.261	- 0.176	0.034	0.011	-0.089	0.111	0.006	1			
Harvest index	- 0.155	- 0.013	- 0.201	0.349*	- 0.18	-0.095	0.106	0.116	1		
Biological yield	0.027	- 0.119	0.356*	0.372*	0.801**	0.238	0.324*	-0.07	- 0.37	1	
Grain yield	- 0.125	- 0.177	0.268	0.645 **	0.838**	0.23	0.282	0.005	0.059	0.813**	1

- * and ** are the significance of 1% and 5%

Table 5. path analysis of 15 genotypes of rain-fed barley

Indirect effects											
	day to heading	day to maturity	plant height	panicle per squqre meter	grain per panicle	Grain wheight	Panicle lenght	Pedanclelenght	Harvest index	Biological yield	Direct effects
grain per panicle		0.005	-0.001	-0.002	-0.001	0.001	0	-0.003	-0.002	0	0.07
grain per panicle	-0.008		0	0.002	0.001	-0.001	0.001	0.001	0	0.001	-0.002
grain per panicle	-0.001	-0.001		0.001	-0.002	-0.004	0	0	0.001	-0.003	0.005
grain per panicle	-0.158	-0.116	0.109		0.203	-0.245	0.145	0.006	0.216	0.23	0.619
grain per panicle	-0.039	-0.082	-0.131	0.197		0.049	0.173	-0.054	-0.108	0.479	0.599
Pedanclelenght	0.07	0.026	-0.253	-0.169	0.035		-0.039	0.047	-0.041	0.101	0.427
Pedanclelenght	0	-0.001	0	0	0	-0.001		0	0	0	0.001
Pedanclelenght	-0.002	-0.001	0	0	-0.001	0	0		0	-0.001	0.004
Harvest index	0.001	0	-0.003	-0.004	0.001	0.001	-0.002	-0.002		0.003	-0.011
Biological yield	-0.001	0	0	0.001	-0.003	-0.001	-0.001	0	0		-0.003
Remained effects	0.053										

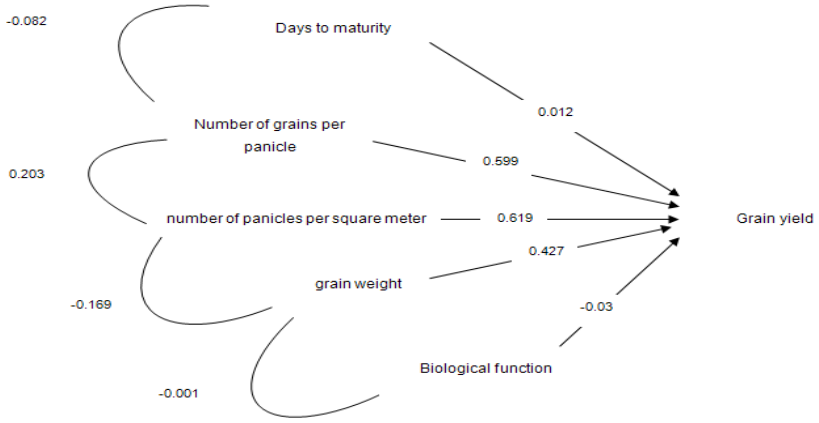

Figure 1.

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