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Comparisons of Seed Yield, Its Components, Phenologic and Morphologic Traits of Iranian Barley Cultivars under Lorestan Weather Condition

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ABSTRACT

BACKGROUND: Barley is one of the main important crops in the world, mainly used for animal feed and malt.

OBJECTIVES: This study was conducted to evaluate the comparisons of seed yield and its components, phenological and physiological traits of different barley cultivars under Lorestan environmental condition.

METHODS: Current research was carried out according Randomized Complete Block Design (RCBD) with three replications in Lorestan environmental condition, Iran during 2017-2018. Treatment included eight barley cultivars (EDCI-7, Nimruz, Armaghan, Jolge, Bahman, Waxima, Vilma, Nosrat and Goharan).

RESULT: According results of analysis of variance the effect of cultivar treatment on day to tillering, day to stem elongation, day to flowering, day to physiological maturity, day to harvesting, plant height, spike length, awn length, number of tiller per plant, number of plant per m^2, number of spike per plant, number of spike per m^2, number of awn per spike, number of seed per spike, 1000 seed weight, seed yield, biological yield and harvest index was significant. The mean comparison result revealed that highest phenological periods were related to Bahman cultivar (223 and 250 days to physiological maturity and harvesting respectively). Also the higher yield components were related to Armaghan and Bahman cultivars. Maximum seed yield and biological yield was recorded for Armaghan cultivar (3660 $kg.ha^{-1}$ seed yield) and Bahman cultivar (11741 $kg.ha^{-1}$ biological yield). But the minimum amount of seed yield and biological yield were recorded in Goharan and EDCI-7 cultivars.

CONCLUSION: Finally based on result of current research between all studied barley cultivars, the Armaghan had the highest seed yield and can proposed to producers for cultivation in Lorestan environmental condition.

KEYWORDS: *Day to flowering, Lodging sensitivity, Physiological maturity.*

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1. BACKGROUND

Barley is one of the main important crops in the world, mainly used for animal feed and malt (Kilsic *et al.*, 2010). Barley (*Hordeum vulgare* L.) is one of the oldest domesticated crops. It was domesticated about 10,000 years ago from it's a two rowed wild progenitor (*H. vulgare* ssp. *spontaneum*) in the region of the Middle East known as the Fertile Crescent (Saroei *et al*., 2017). Based on FAO (2016) Barley is ranked as fourth cereal crop after wheat, maize, wheat and rice in the world. Under low rainfall conditions barley is preferred by many farmers. The increase in barley yields over the recent period has largely been an effect of the introduction of new more productive cultivars into farming practice. Potential seed yield of a given cultivar depends on various characters making up the plant growth habit (Noworolnik, 2012). Seed yield is a quantitative trait, which expression is the result of genotype, environmental effect and genotype-environment interaction (Gunasekera *et al*., 2006). The yield of barley is depending of many factors such as genetic property, nutrition and environmental condition. The genotypic traits of a variety and growing climatic conditions are the key factors influencing seed yield and its quality (Leistrumaitë and Paplauskienë, 2005). The Environmental conditions around 20 days pre- and 10 days post-anthesis are considered critical for seed yield determination (Savin and Slafer, 1991). The final seed number per unit area is set immediately after anthesis, while seed filling occurs during the remaining post-anthesis period (Ugarte *et al*., 2007). During pre-anthesis, the potential seed number per unit area (Fischer, 1985) and potential seed weight (Calderini *et al*., 2001) are defined. However, this association has been extensively reported for a relatively wide range of environments. However, the first step to success for higher production of barley in a certain environment is the choice of proper cultivar. Barley has been cultivated for many years and has significant role in dry areas of Lorestan, Iran. The region's climate is semi-arid (annual precipitation rate 369 mm) with mild-hard winter weather which enable winter barley to perform well. Differences in spike and dormancy characteristics among varieties will influence germination percentage (Australian, 2008) and by extension, determine the plant stand establishment and in finally barley seed yield (Mckenzie *et al.,* 2005). Varietal differences in the number of seeds per spike are associated with its relatively higher heritability of 98% when compared to other yield components (Rao *et al.,* 2012). Genetic effect on seed size was found to be greater than environmental effect even when experimental sites suffered terminal moisture stress, with retention value of 88 to 96% (Glen *et al.,* 2006). Phenology is broadly defined as the study of recurring plant and animal life cycle stages, especially their timing and relationships with weather and climate (Schwartz, 2003). The profitability of barley depends on both crop yield and quality (seed protein, seed size). Yield and quality may be influenced by weather, fertilizer management and cultivar selection. The productive tillering ability of plants, that is, their ability to produce an optimally large number of ears in the crop, is of special significance (Fatyga *et al*., 1993). Barley cultivars with lower tillering ability have been observed to respond stronger to increased nitrogen fertilization rates by increasing yield (Lauer *et al*., 1990). However, there is a lack of information on different responses of new barley cultivars to delayed sowing date as expressed by plant morphological charac-

ters and seed yield. In Iran the frequent prolonged persistence of winter conditions forces delayed sowing time of spring cereals. Decreased yields of some barley cultivars in certain conditions should be compared in relation to plant morphological characters that strongly affect seed yield.

2. OBJECTIVES

This research was conducted to evaluate the comparisons of seed yield and its components, phenological and physiological traits of different barley cultivars under Lorestan condition.

3. MATERIAL AND METHODS

3.1. Field and Treatments Information

Current research was carried out to evaluation morpho-physiologic characteristics of barley cultivars according Randomized Complete Block Design (RCBD) with three replications in lorestan environmental condition, Iran during 2017-2018. Treatment included eight barley cultivars (EDCI-7, Nimruz, Armaghan, Jolge, Bahman, Waxima, Vilma, Nosrat and Goharan). The place of experimental farm was located in Dorud area. The soil type was a clay loam, pH of 7.8 and EC= 0.43 $ds.m^{-1}$. The Dorud region has a semi-arid climate conditional with annual precipitation of 369 mm. About 55 of rainfall were taken during the barley growing period. There were eight rows in each plot; rows were 1 m long with 0.2 m row spacing. Barley seeds were sown at 180 $kg.ha^{-1}$ on 12 November 2017.

3.2. Measured Traits

Phonological traits were measured during growing season. Also morphological traits were measured. At maturity, two outer rows for each plot, 25 cm from each end of the plots, were left as borders and the middle 1 m^2 of the two central rows were harvested for economic and biological yield determination. Each sample was oven dried at 80 ^0C and seed yield measured. The row in spike and lodging sensitivity were analyzed visually. Harvest index (HI) was calculated according to formula of Gardner *et al*. (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

3.3. Statistical Analysis

Data were analyzed with SAS (Ver.8) software. Means were compared via LSD test at 5% probability level.

4. RESULTS

4.1. Phenological traits

According results of analysis of variance effect of different cultivar of barley treatment on all of phenological traits such as day to tillering, day to stem elongation, day to flowering, day to physiological maturity and day to harvesting (instead day to emergence) was significant (Table 1). The results of mean comparisons revealed there were no significant differences between cultivars for day to emergence. However, results shows that Bahman cultivar had highest day to tillering, day to stem elongation, day to flowering, day to physiological maturity and day to harvesting in rate of 92, 160, 185, 223 and 250 days respectively (Table 2). Also between eight barley cultivars, Goharan had lowest day to tillering, day to stem elongation, day to flowering, day to physiological maturity and day to harvesting in rate of 80, 152, 165, 207 and 238 days and its differences was significant in comparison with Bahman cultivar. Bahman cultivar has no significant differences with EDCI-7 cultivar for some phonological stages such as day to emergence, day to tillering, day to stem elongation, day to flowering, day to physiological maturity and day to harvesting (Table 2).

Table 1. Analysis of variance effect of cultivar on phenological traits

S.O.V	df	Day to emergence	Day to tillering	Day to stem elongation	Day to flowering	Day to physiological maturity	Day to harvest
Cultivar	8	88^{ns}	175**	199**	212*	225*	255*
Repeat	2	46.5	96	101	145	165	211
Error	16	72	102.7	142	196	186	225
CV (%)	-	11	6.3	11.2	10	9.5	6.6

^{ns}, *and ** are non-significant and significant at 5% and 1% probability levels, respectively.

4.2. Morphological traits

Results of analysis of variance revealed that the effect of cultivar treatment morphological traits such as plant height, spike length and awn length was significant at 1% probability level (Table 3). The mean comparison results showed that the Waxima cultivar had the highest plant height (102 cm) but between eight barely cultivars, the Bahman cultivar had lowest height (71 cm). Based on mean comparison results, the Vilma cultivar had the highest spike length (10.54 cm) and the Bahman had the lowest spike length (5.12 cm) and differences between them were significant. However, the maximum awn length was founded in Bahman cultivar (19.6 cm) and don't have significant difference in comparison with Vilma cultivar (Table 4). The lowest awn length was obtained in EDCI-7 cultivar (14.11 cm) and don't have significant difference compared to Nimruz, Waxima and Nosrat cultivars (Table 4).

Table 2. Mean comparisons effect of cultivar on phenological traits

Cultivars	Day to emergence	Day to tillering	Day to stem elongation	Day to flowering	Day to physiological maturity	Day to harvest
EDCI-7	21^{a}	91^{a}	158^{ab}	178^{ab}	217^{ab}	242^{ab}
Nimruz	21^{a}	90^{a}	156^{ab}	177^{ab}	211^{b}	239^{b}
Armaghan	20^{a}	82^{b}	157^{ab}	171^{b}	211^{b}	242^{ab}
Jolge	20^{a}	88^{ab}	156^{b}	182^{a}	211^{b}	242^{ab}
Bahman	21^{a}	92^{a}	160^{a}	185^{a}	223^{a}	250^{a}
Waxima	20^{a}	84^{b}	156^{b}	175^{b}	217^{ab}	245^{ab}
Vilma	21^{a}	82^{b}	156^{b}	172^{b}	217^{ab}	245^{ab}
Nosrat	21^{a}	82^{b}	154^{b}	179^{ab}	209^{b}	239^{b}
Goharan	20^{a}	80^{b}	152^{c}	165^{b}	207^{b}	238^{b}

*Similar letters in each column show non-significant difference at 5% probability level, via LSD test.

4.3. Seed yield and its components

According the results of analysis of variance the effect of cultivar on seed yield and its components traits (such as number of tiller per plant, number of plant per m^2, number of spike per plant, number of spike per m^2, number of awn per spike, number of seed per spike, 1000 seed weight, seed yield, biological yield and harvest index) was significant (Table 5). The results of mean comparison showed that the Armaghan cultivar had the highest number of tiller per plant (19 tillers) and Nosrat cultivar had the lowest one (3.3 tillers). The Nimruz and Bahman cultivar had the highest plant per m^2 (68 plants per m^2) but the EDCI-7, Jolge and Goharan cultivars had the lowest one (48 plants per m^2). The EDCI-7 cultivar had the maximum spike per plant (14 spikes per plant) and had no significant difference compared

with Armaghan and Bahman cultivars (13 spikes per plant). The lowest spike per plant was obtained for Goharan cultivar (7 spikes per plant). The mean comparison results showed that highest number of spike per m^2 was recorded in Bahman cultivar (884 spikes per m^2) and had a significant difference in comparison with other cultivars. After this cultivar, Armaghan Waxima and Nimruz had higher spike per m^2 (780, 704 and 680 spike per m^2 respectively). Also the lowest spikes per m^2 were recorded in Goharan cultivar (336 spikes per m^2) (Table 6).

Table 3. Analysis of variance effect of cultivar on morphological traits

S.O.V	df	Plant height	Spike length	Awn length
Cultivar	8	13.3**	1.3**	0.23**
Repeat	2	8.5	0.8	0.11
Error	16	9.45	0.6	0.15
CV (%)	-	7.7	5.5	7.6

ns, *and ** are non-significant and significant at 5% and 1% probability levels, respectively.

Table 4. Mean comparisons effect of cultivar on morphological traits

Cultivar	Plant height (cm)	Spike length without awn (cm)	Awn length (cm)
EDCI-7	87^{b}	9.66^{ab}	14.11^{bc}
Nimruz	83.6	7.14^{bc}	13.42^{c}
Armaghan	94.3^{ab}	7.54^{bc}	15.02^{b}
Jolge	91.6^{ab}	9.02^{ab}	15.42^{b}
Bahman	71^{c}	5.12^{d}	19.9^{a}
Waxima	102^{a}	$7.9b^{c}$	14.16^{bc}
Vilma	98.6^{a}	10.54^{a}	19.6^{a}
Nosrat	77.6^{bc}	6.4^{c}	14.2^{bc}
Goharan	84^{b}	$7.1b^{c}$	10.3^{d}

*Similar letters in each column show non-significant difference at 5% probability level, via LSD test.

Number of awns per plant was differed between all cultivars and Nosrat cultivar had the highest awns per plant (56 awns per plant). The Nosrat cultivar had no significant difference in comparison with Armaghan, Jolge and Waxima cultivars but had significant difference with other cultivars (Table 6). Maximum number of seed per spike (61.6 seed per spike) was obtained in Bahman cultivar and Minimum seed per spike was recorded in Nimruz cultivar (20.3 seed per spike). The 1000 seed weight was differed between all cultivars and highest 1000 seed weight was recorded in Vilma, EDI-7 and Nimruz cultivars (41.46, 41.04 and 40.6 g respectively). The Bahman cultivar had the lowest 1000 seed weight (26.58 g) and there was no significant difference in comparison with Waxima cultivar (31.08 g). The results show that seed yield was differed between all eight barley cultivars. Maximum seed yield was obtained in Armaghan cultivar (3660 $kg.ha^{-1}$) and followed by Bahman cultivar (3640 $kg.ha^{-1}$) and their difference was not significant. So the minimum seed yield was obtained in Goharan cultivar (1500 $kg.ha^{-1}$) and its difference was not significant in comparison with EDCI-7 cultivar (1600 $kg.ha^{-1}$).

Table 5. Analysis of variance effect of cultivar on seed yield and its components

S.O.V	df	Number of tillers per plant	Number of plant per m^2	Number of spike per plant	Number of spike per m^2	Number of awn per spike
Cultivar	8	0.18*	36**	0.21**	23165*	66*
Repeat	2	0.08	21	0.13	2526	91
Error	16	0.31	28	0.25	3265	45
CV (%)	-	9.1	9.5	7.2	11.1	10.2

^{ns}, *and ** are non-significant and significant at 5% and 1% probability levels, respectively.

Continue Table 5.

S.O.V	df	Number of seed per spike	1000 seed weight (g)	Seed yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Harvest index (%)
Cultivar	8	86*	35.1**	152365**	32565236**	11.3*
Repeat	2	111	14.3	10236	2365845	7.1
Error	16	74.5	21.2	23025	1212526	9.2
CV (%)	-	8.6	8.7	5.2	9.3	8.5

^{ns}, *and ** are non-significant and significant at 5% and 1% probability levels, respectively.

The results of mean comparison showed that between cultivars, maximum biological yield was obtained in Bahman cultivar (11741 $kg.ha^{-1}$) and had significant difference in comparison with other cultivars. So by Bahman cultivar, the highest biological yield was ranked in Vilma, Armaghan and Jolge cultivars in rate of 10866, 10457 and 10214 $kg.ha^{-1}$, respectively. The HI was differed between all eight cultivars, and maximum HI was founded in Armaghan cultivar (35%) and minimum HI was recorded in EDCI-7 and Goharan cultivars (25%) (Table 6).

4.4. Mean of row per spike and lodging sensitivity of barley cultivars

Visual analysis for number of rows per spike shows that EDCI-7, Nimruz and Vilma cultivars had two seed rows per each spike but Armaghan, Jolge, Bahman, Waxima, Nosrat and Goharan cultivars had six rows per spike for seed production. The number of rows per spike is a genetic property of barley cultivars and don't affected by environmental conditions (Table 7). The results for lodging sensitivity shows that Armaghan and Goharan were sensitive to lodging in rate of 10% but other cultivars were not sensitive to lodging (Table 7). These results shows that Armaghan and Goharan cultivars must cultivated in a lower plant density to avoiding of lodging.

5. DISCUSSION

In the present study there are differences between phonological stages and morphological traits. Also yield components such as number of tillers was differed between all cultivars so that Armaghan cultivar had highest number of tiller par plant (19) that result to higher seed yield production in this cultivar in comparison to other barley cultivars. However, between all cultivars, the Nosrat cultivar had lowest number of tiller per plant (3.9) and its differences were significant in comparison with other cultivars. In former studies differences of up to 20% in fertile tiller numbers per plant have been observed (Tambussi *et al.,* 2005). However, other studies show that environment has a lower influence on barley tillering and that genetics has more influence due to its low variability across different environments (Tamm, 2003).

Table 6. Mean comparisons effect of cultivar on seed yield and its components

Cultivars	Number of tillers per plant	Number of plant per m^2	Number of spike per plant	Number of spike per m^2	Number of awn per spike
EDCI-7	11.3^{b}	48^{c}	14^{a}	672^{d}	24^{cd}
Nimruz	12.3^{b}	68^{a}	10^{b}	680^{cd}	16.2^{d}
Armaghan	19^{a}	60^{b}	13^{a}	780^{b}	52.2^{a}
Jolge	9^{c}	48^{c}	11^{b}	528^{f}	54.2^{a}
Bahman	11^{b}	68^{a}	13^{a}	884^{a}	46.2^{b}
Waxima	7.6^{c}	64^{ab}	11^{b}	704^{c}	55^{a}
Vilma	7^{c}	60^{b}	11^{b}	660^{d}	30.6^{c}
Nosrat	3.3^{d}	56^{bc}	10^{b}	560^{e}	56^{a}
Goharan	8.6^{c}	48^{c}	7^{c}	336^{g}	44.2^{b}

*Similar letters in each column show non-significant difference at 5% probability level, via LSD test.

Continue Table 6.

Cultivars	Number of seed per spike	1000 seed weight (g)	Seed yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Harvest index (%)
EDCI-7	26.3^{c}	41.04^{a}	1600^{f}	7025^{g}	25^{c}
Nimruz	20.3^{c}	40.6^{a}	2260^{d}	8542^{e}	27^{bc}
Armaghan	60.3^{a}	39.34^{ab}	3660^{a}	10457^{bc}	35^{a}
Jolge	47^{b}	36.34^{b}	2860^{c}	10214^{c}	28^{bc}
Bahman	61.6^{a}	26.58^{d}	3640^{a}	11741^{a}	31^{b}
Waxima	57.6^{a}	31.08^{cd}	2820^{c}	9724^{d}	29^{bc}
Vilma	26.6^{c}	41.46^{a}	3260^{b}	10866^{b}	30^{b}
Nosrat	45.6^{b}	37.4^{ab}	1920^{e}	7348^{f}	26^{c}
Goharan	42.6^{b}	33.88^{b}	1500^{f}	7125^{fg}	25^{c}

*Similar letters in each column show non-significant difference at 5% probability level, via LSD test.

In Lorestan environmental condition, the Armaghan cultivar had better response for number of tiller per plant. Bahman and Nimruz cultivars has higher number of plant per area (68 plants) and higher number of spike per area, but highest number of spike per m^2 was related to Bahman cultivar (884) and its difference was significant compared to other cultivars. Based on the present results, there are differences between barley cultivars in terms of response to Lorestan environmental condition, so that they are different yield and yield components. In this case, long term field studies showed a significant difference between yield productions of field crops cultivars. Varying of yield components is the main reason to different seed yield in barley cultivars. Seed yield in different cultivars was mainly determined by seed number per unit area. Seed yield variability was the result of the potential growing conditions in each location generated by differences in cultivars and its distribution during the vegetative and reproductive stages. This was also reported in other studies (Austin *et al.*, 1998). In this experiment Armaghen and Bahman cultivars were suitable for Lorestan environmental condition due to higher seed production (3660 and 3640 kg.ha-1 respectively) and there were no significant difference with them. Increasing of seed yield in Armaghen and Bahman cultivars is depend to better acclimation to Lorestan condition.

Table 7. Mean of row per spike and lodging sensitivity of barley cultivars by visual assessment

Cultivar	Number of row per spike	Lodging sensitivity
EDCI-7	2	0
Nimruz	2	0
Armaghan	6	10
Jolge	6	0
Bahman	6	0
Waxima	6	0
Vilma	2	0
Nosrat	6	0
Goharan	6	10

According to Wheeler *et al*. (2000), factors like weather and soils are important causes for crop yield variability. In this experiment we concluded that seed yield and its components varied from cultivar to cultivar. A higher seed yield was recorded for the Armaghen and Bahman cultivars (Table 2). The EDCI-7 and Goharan cultivars produced lowest seed yield and biological yield between all cultivars and there is no significant difference between these two cultivars. Differences between cultivars are referred to genetic difference and response to environment condition. The Armaghan and Bahman cultivars had a positive response to Lorestan environmental condition that produced higher seed and biological yield between all cultivars. The higher row per spike result to higher number of seed per plant and influence to higher seed yield production. However, Armaghan and Bahman cultivars had highest number of seed per spike and followed produced higher seed yield. However, Bahman cultivar had lowest 1000 seed yield but produced higher seed yield. Large differences in seed yield have been observed by many studies but the yield stability across different weather conditions was high (Tamm, 2003). This results identified that seed yield is not depended to seed weight only. 1000 seed weight is a genetic trait that is very low affected by environment. Similar studies also found a very high heritability value for 1000 seed weight of 99.9% (Nanak *et al.,* 2008). Alam *et al*. (2007) demonstrated that seed weight is not a major contributor to variation in seed yield among barley cultivars. The number of seed per spike is one of the main factor affecting on final seed yield that seen in the present study. Bahman cultivar had the lowest plant height but had the longest phonological period. Longer phonological period result to higher photosynthetic production and translate to reproductive sinks that increased seed yield. So, longer growth period result to longer vegetative growth, that affected on biological yield. This result confirms earlier observations by Hay and Walker (1989) and Birch and Long (1990). Number of seeds per productive tiller is also associated with cultivar effects on yield (Hay and Walker, 1989), but no measurements were made of this parameter in this study. Barley cultivars show different capacities to adapt to different environments e.g. moisture stress and soil fertility (Aynewa *et al.,* 2013). This can led to differences in yield and quality components with more fertile tillers per plant and number of seed per spike making major contributions to yield (Jalal and Ahmad, 2011).

6. CONCLUSION

Between all barley cultivars, Armaghan had the highest seed yield and can proposed this cultivar to farmers for cultivation in Lorestan condition.

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