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Evaluation of Yield and Some Characteristics of Ten Spring Barley (*Hordeum vulgare*) Varieties under Limited and non Limited Irrigation

Saeid Yazdchi
Department of Agriculture, Islamic Azad University, Marand Branch, Marand, Iran

Abstract: In order to evaluate yield and some morphological characteristics of 10 spring barley verities under non limited and limited irrigation (irrigation until flowering) an experiment as two design based on Randomized Complete Block (RCB) with there replications were carried out. All varieties had no difference in the number of kernel per spike and flag leaf area two irrigation regimens. The irrigation treatments affected all measured traits except awn length, spike length and no of kernel per spike of main stem. The genotypes and irrigation treatment interaction had significant effects on grain yield and growing period. In non limited irrigation treatment Atlas 76/Kavir and Gorgan/CM67/Pro/Suo varieties had higher grain yield than other varieties, whereas, Suifu/Walfajre, Rihane/Alger-union, Atlas 46/Kavir and Gorgan/CM67/Pro/Suo produced highest yield. There varieties had greater STI (Stress Tolerance Index) compared to other varieties and showed more resistance to drought stress at flowering-grain filling period.

Key words: Spring barley, water stress, yield, Irrigation, Randomized Complete Block (RCB)

INTRODUCTION

Iran with 260 mm annum^{-1} of rainfall is one of the semidry countries and nearly half of the available lands are in dry and semidry lands. Barley is one of main crop grown in Iran because it is adapted to a severe water regime compared with other cereal (Gonzalez *et al*., 1999; Voltas *et al*., 1999; Sanchez-Daiz *et al*., 2002; Benmoussa and Achouch, 2005). However, its productivity is limited by terminal drought stress at this critical stage of development needs to be studied to understand adaptation of barley plants to postanthesis drought stress. Whether severity of postanthesis drought stress is a determinant factor for grain yield needs to be studied. Such information is important for plant breeders to select traits for drought tolerance and for farmer for better crop management to avoid the occurrence of a drought period at the critical stage of development.

The effects of drought stress on grain growth and yield have been studied in cereal crops (Jamieson *et al*., 1995a, b; Gonzalez *et al*., 1999). Drought stress during the grain-filling period decreased the net photosynthetic rate of the flag leaf of barley, but had no significant effect on the grain-filling rate under high vapor pressure deficit (Sanchez-Daiz *et al*., 2002). The flag leaf and ear is the main photosynthetic organs to provide assimilates for grain filling, particularly in environments where drought is encountered at the end of the plants life cycle (Sanchez-Daiz *et al*., 2002; Samarah, 2005). The capacity to remobilize vegetative reserves seems to be responsible for maintaining the grain growth rate under drought stress (Benmoussa and Achouch, 2005; Samarah, 2005).

In the semidry areas, the spring barley varieties in final stages of growth are usually encountered with waterlessness and water stress difficulty, so to introduce the barley varieties, which have the ability to endure the drought and have the high yield and experiment with using the 10 barley varieties was carried out of the end of growth period in spring 2006.

MATERIALS AND METHODS

Ten types of barley varieties which were arranged in 6 rows were used in this experiment. In order to make easy doing and calculating this experiment, each one of the varieties has indicated with a number in Table 1.

In this experiment 10 barley varieties, in 2 separate experimental designs are studied together. Randomized complete block design used in this experiment was with 3 replications. Every one of the experiments was in the same condition and the only existing difference among them was stopping the irrigation in one of the experiments at earring stage till complete maturity stage.

Every variety in an experimental unit is composed of 2 rows, which are 60 cm in width and every row includes 2 rows, which are 5 mL and the distance between them is 30 cm, were planted, so that the area of every experimental unit at all blocks is $4 \times 0.3 \times 5 = 6$.

Table 1: Number of each one of varieties

Number	Name
1	Local
2	Rihane
3	Rihane/Alger-union
4	Atlas 46/kavir
5	Gorgan/CM 67/pro/suo
6	Sufia/walfajre
7	Qc 2.17×d1/Bgs
8	Kavir/Badia
9	Rihane-05
10	As -46/ Aht 2-2 AD

Place of experiment was 1349 m in height. Its longitude is 46°45' eastern length and it s latitude is 38°15' northern width. Absolute maximum and minimum of temperature in this place is -22 and 39°C and average rainfall is 300 mm per annum. Soil tissue in this area is lomy and has a rather quick infiltration. Measure of existing salt in the irrigation water is between 3000 and 6000 μmhos cm^{-1}.

Under consideration attributes

Grain yield: After separation of grain from straw, the weight of grain is calculated in terms of Gramme in every experimental unit.

Awn length: The awn length in middle spike lets is measured from middle part of spike.

The time of maturity: The time of Maturity is calculated in terms of day from cultivation till ripping of 95% plants of every plot.

The grain numbers in main spike: The total numbers of grains are counted in main stem of spike.

Flag leaf area: The flag leaf area is calculated from multiplying length by width of flag leaf.

We took the advantage of Mstatc, SAS, SPSS and statistica programs in analyzing of research data of statistical accounts and using of QPRO program in graph drawing.

RESULTS AND DISCUSSION

Analysis of variance: Experiments without drought stress. The analysis of variance consults have come in Table 2.

There is a significant difference between varieties which are under consideration and all attributes expect attributes of grain number in main spike and flag leaf area that show genetically differences between under consideration varieties.

Analysis of variance: Experiment of drought stress: The consults are shown in Table 3.

The significant difference that is due to existence of genetically difference between varieties of majority of attributes have been observed between varieties of all under consideration attributes except grain numbers in main spike and leaf area.

Combined analysis of varieties in both environments: In due attention to Table 4, there is not significant difference between source of environment changing and attributes of awn length and grain numbers in main spike, but there is significant difference between all attributes of genotypes, except grain numbers in main spike.

The interaction of multiplying Genotype×Environ ment is significant for attributes if action and time of maturity that shows difference in reaction of genotypes for purpose of mentioned attributes in both experiments.

Mean comparison of under consideration attributes: According to Duncan's Test, mean comparison of under consideration attributes is 5% which come separately with related LSD to experiments without drought stress, experiments of drought stress and combined analysis of both environments (Table 5-7).

Grain yield: The significant interaction of multiplying Genotype×Environment is aroused from reaction of genotypes on various environmental conditions.

In stress less condition (Table 5), numbers of 5, 1, 4 are in higher grain function position with compared to other numbers and in drought stress condition (Table 6) numbers of 4, 6, 3, 1, 5 have approximately same grain function and are classified in the same group. whereas the number of 5 that in stress less condition had a good and remarkable function, show a poor grain function after applying of drought stress, so it presents, sensitiveness of this number to drought stress in flowering stage. In drought stress environment, number of 4, 6 and 3 have the smallest subsidence in grain function, respectively. So, it can be said that in conditions of stress less, number of 5 and in conditions of drought stress, numbers of 4, 6 are suitable, respectively.

With due attention to significant effect of environment (Table 4) and to decrease of all numbers in stressful environment with regard to stress less environment, it can be concluded that there is a meaningful difference between two environment with regard to function and it is correspondent to other research results. They believe that decrease of photosynthesis after flowering as the result of drought stress, derange transmission of dried material produced before earring to seed, so it would have an effect on ultimate function of seed.

Maturating period: Mutual effect of Genotype× Environment is significant and it is shown in Table 4.

Table 2: Analysis of variance (experiments without drought stress)

		Mean of squares				
Source of variation	Degree of freedom	Grain yield	Awn length	Time of maturity	The grain numbers in main spike	Flag leaf area
Replication	2	202559.1	1.67	1.9	0.028	0.448
Genotype	9	1873000.5**	3.93**	4.67*	0.019	0.245
Error	18	186802.3	0.731	1.38	0.012	0.127
CV	-	15.8	8.67	1.15	7.73	16.09

Table 3: Analysis of variance (experiments of drought stress)

		Mean of squares				
Source of variation	Degree of freedom	Grain yield	Awn length	Time of maturity	The grain numbers in main spike	Flag leaf area
Replication	2	332111.1	0.34	21.23	0.008	0.605
genotype error	9	552987.6*	2.38*	23.34**	0.009	0.241
	18	213716.3	0.741	3.38	0.02	0.269
CV	-	22.18	9.03	2.00	10.27	19.740

Table 4: Combined analysis of varieties in both environments

		Mean of squares				
Source of variation	Degree of freedom	Grain yield	Awn length	Time of maturity	The grain numbers in main spike	Flag leaf area
Environment	1	62942287**	1.614	2444.81**	0.005	0.003
Error	4	176185.1	0.254	11.56	0.018	0.037
Genotype	9	1780821.2**	5.33**	6.98**	0.020	0.015*
Environment×Genotype	9	645166.8**	0.99	21.03**	0.008	0.063
Error	36	200259.2	0.786	2.38	0.016	0.006
CV	-	18.56	8.85	1.62	9.070	11.330

Table 5: Experiments without drought stress

Genotype	Grain yield	Awn length	Time of maturity
5	4083.3a	10.2b	102bc
1	3666.7a	9.4bc	101c
4	3500ab	9.4bc	104.7a
6	2933.3bc	9.5bc	102bc
3	2666.7cd	12.7a	100.7c
8	2500cde	9.9bc	101c
10	2183.3de	8.3c	101.3bc
9	2083.3de	9.2bc	102bc
7	1894.4e	10b	101c
2	1833.3e	10.1b	103.3ab
	2734.4	9.9	101.9
LSD 5%	611.9	1.45	2.016

Table 6: Experiments of drought stress

Genotype	Grain yield	Awn length	Time of maturity
4	2722.2a	8.7b	82.7c
6	2666.7ab	9.7b	91.3a
3	2522.2abc	11.7a	88.3b
1	2166.7abcd	8.7b	91.67a
5	2055.7abcd	9.6b	86.3b
9	1966.7bcd	9.9b	91a
8	1833.3cd	9.6b	90.3a
7	1806cd	9.5b	89.3b
2	1666.7cd	8.5b	89b
10	1466.7d	9.5b	91a
	2086.7	9.5	89.1
LSD 5%	654	1.48	3.154

Number of 7 with average if 61 days and number of 4 with average of 48 days have maximum and minimum duration of growing, respectively. In stress less environment, number 4 with average growing duration of 104.7 days, had maximum amount of duration. This number has the minimum amount of growing duration with regard to other numbers (Table 5). With due attention to these duration it can be said that grain filling period in this number in stress less conditions is maximum compared to other numbers.

Table 7: Combined analysis of both environments

Genotype	Grain yield	Awn length	Time of maturity	Flag leaf area
4	3111.1a	9b	93.7d	4.50
5	3069.4a	9. 9b	94.2cd	4.20
1	2916.7a	9.1b	96.3ab	8.20
6	2800a	9.6b	96.7a	4.30
3	2594ab	12.2a	94.5bcd	3.70
8	2166bc	9.8b	95.7abcd	3.50
9	2025c	9.5b	96.5ab	3.80
7	1847.2c	9.8b	95.2abcd	7.20
10	1825c	8.9b	96.2abc	6.20
2	1750c	9.3b	96.3ab	3.80
	2410.55	9.7	95.5	4.95
LSD 5%	524	1.031	1.807	2.63

In the stressful conditions (Table 6) numbers of 1, 6, 9, 10, 8, 2, 7, 3 are classified in the same group and they didn't have much more differences, but number of 4,5 are lower than those and it shows a remarkable decrease in the time of maturity and this presents, the effect of drying stress in reproductive stage.

Other researches show that stresses which generated after anthesis and in initial stage of grain generation, cause to acceleration of phonological stage such as the time of maturity.

Numbers of 4 and 5 are early maturity and in fact their producing period on less coincident with unfavorable condition of summer season.

Table 8: Correlation coefficients between resistances to drought index

-	Yp	Ys	MP	TOL	SSI	STI
Yp	1	0.558	0.945**	0.84*	0.715*	0.914**
Ys		1	0.799**	0.018	-0.151	0.841**
MP			1	0.616	0.459	0.994**
TOL				1	0.96**	0.551
SSI					1	0.395
STI						1

Table 9: Function in stress less condition and drought

Genotype	Yp	Ys	MP	TOL	SSI	STI
1	3666.70	2166.70	2916.70	1500.00	1.722	1.620
2	1833.40	1666.70	1750.00	166.60	0.383	0.408
3	2666.70	2522.20	2594.50	144.50	0.228	0.899
4	3500.00	2722.20	3111.10	777.80	0.937	1.274
5	4083.30	2055.70	3069.50	2027.60	2.090	1.122
6	2933.30	2666.70	2800.00	266.60	0.283	1.046
7	1894.40	1800.00	1847.20	94.40	0.210	0.456
8	2500.00	1823.30	2166.60	666.70	1.122	0.613
9	2083.30	1966.70	2025.00	116.60	0.236	0.548
10	2183.30	1466.70	1825.00	716.60	1.382	0.428
Average	2734.43	2086.66	2410.55	647.74	0.869	0.785
CV	28.89	20.57	23.84	101.24	81.240	41.880

Average comparison of other specifications: In this study, for attributes which are considered the mutual effect of Environment×Genotype is not significant in compound analysis (Table 4). So, we would just consider to average comparisons of 2 environments (Table 7). Number of 3 with average of 12.2 cm and number of 10 with average of 8.9 cm were composed of the longest and shortest awn. Number of 1 with flag leaf area of 8.2 cm^2, has a maximum size with regard to this specification in two environments.

The longest spike is relevant to number of 1 and the smallest one is number 8 with enlarging of length of the spike, amount of the grain increases. It means that increase in grain function take place by means of enlarging of length, relevant to increase of the amount of grain in spike.

Correlation coefficients between resistances to drought index: According to Table 8, correlation index STI is positive and significant with Ys, Yp. Maximum amount for index, shows good function for number of 4, 6, 1 with more STI, had a good function in stress less condition and drought too (Table 9) with due attention to this fact that STI index, chose numbers according to high stress resistance and good function and also with due attention to positive and significant correlation that among considered index, STI would be in center of attention and will be important to be chosen and in the second place, MP index would be important which shows a good and significant correlation with STI index.

CONCLUSION

All varieties had no difference in the number of kernel per spike and flag leaf area two irrigation regimens. The irrigation treatments affected all measured traits except awn length, spike length and no of kernel per spike of main stem. The genotypes and irrigation treatment interaction had significant effects on grain yield and growing period. In non limited irrigation treatment Atlas 76/Kavir and Gorgan/CM67/Pro/Suo varieties had higher grain yield than other varieties, whereas, Suifu/Walfajre, Rihane/Alger-union, Atlas 46/Kavir and Gorgan/ CM67/Pro/Suo produced highest yield. There varieties had greater STI (Stress Tolerance Index) compared to other varieties and showed more resistance to drought stress at flowering-grain filling period.

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