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Evaluation of quantitative and qualitative characteristics of yield in dryland wheat cultivars under supplemental irrigation conditions

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Abstract

Field experiments were conducted to evaluate quantitative and qualitative characteristics of yield in dryland wheat cultivars under supplemental irrigation conditions. In these split plots randomized complete block design experiments were used, the main plots consisted of five irrigation treatments while sub plots consisted of three dryland wheat cultivars. Results showed that supplemental irrigation increased wheat cultivars yield compared to control (no irrigation). Sardari cultivar produced the highest yield with two times supplemental irrigations at planting and flowering stages. The highest grain N content was found in $Azer_2$ cultivar under no irrigation conditions. In general, application of one time supplemental irrigation at flowering stage significantly increased grain yield in Sardari cultivar.

Key words: Cultivar, dryland wheat, grain yield, supplemental irrigation, N content**.**

Introduction

In arid and semiarid areas the most limiting natural resource is water and rainfall is the main source for food grains production [1]. The rainfed areas occupy an important role in the production of food in many countries of the world. They cover more than 80% of the land area used for cropping throughout the world and produce 60% of the total production [2]. In Iran more than 65% of agricultural lands are managed under rainfed conditions [3]. Dryland farming is a risky enterprise because severe variability of annual rainfall, its irregular distribution and also excessively high or low temperatures can damage crops or limit growth and yield in these areas [4]. Yields and water productivity are greatly enhanced by the conjunctive use of rainfall and limited irrigation water [5]. Supplemental irrigation is defined as the application of a limited amount of water to rainfed crops when precipitation fails to provide the essential moisture for normal plant growth in dryland regions [6-8]. Application of limited amount of supplemental irrigation besides increasing yield can also stabilize yield from year to year in dryland conditions [9]. Kamal *et al.* [10] reported that application of supplemental irrigation improved the plant characteristics like grain and straw yields in wheat grains compared to grains grown under rainfed conditions.

Moisture stress during sensitive stages of crop growth usually causes a collapse in the crop yield. When supplemental irrigation is applied before the occurrence of stresses, the plant may produce its potential [5]. Soltani *et al.* [11] showed that a supplementary irrigation between flowering and seed filling stages can increase seed yield of chickpea in environments and years with low amounts of rainfall during the reproductive stage. Tadayon and Emam [12] reported that supplemental irrigation at sensitive stem elongation stage could affect significantly wheat grain yield of rainfed wheat cultivars, and provision of adequate water for a supplemental irrigation at the appropriate growth stage could double the grain yield of rainfed wheat. An experiment for evaluating effects of supplemental irrigation on annual ryegrass indicated that in drier years than the normal even a small amount of water can increase and stabilize forage production [13]. Stark and Longley [14] reported that adequate early-season soil water availability can result in developing uniform tillering patterns and high yield potential for spring wheat.

The grain yield and protein content of wheat are reported to be influenced by genotypes grown under different management practices [15, 16]. Assessment of supplemental irrigation effect on dryland wheat genotypes yield showed that the Sabalan cultivation in dryland west region of Iran and its irrigation at least one time at milking stage can increase grain yield [9]. Karimirad *et al.* [17] stated that application of a supplemental irrigation in dryland wheat cultivar namely Koohdasht at stem elongation stage increased grain yield by 48%.

The objectives of this study were to evaluate the effects of supplemental irrigation on grain yield and quality of three dryland wheat cultivars, and to find the most suitable cultivar and the best time of application of supplemental irrigation for Western Azerbaijan of Iran.

Materials and Methods

The research was conducted in 2004 and 2005 at the Miandoab Agricultural Research Station in Western Azerbaijan of Iran (36°582N, 46°102E; elevation 1314 m). Average annual precipitation was 289.6 mm. The soil was clay loam, having pH 6.85 in 2004 and 6.92 in 2005. Plots were fertilized according to soil analysis and

provincial recommendations in both years. The experiments were done as a split plots design based on randomized complete block design with four replications. The main plots consisted of five irrigation treatments including no irrigation (control) I_1, one time irrigation at planting stage I_2, one time irrigation at flowering stage I_3, one time irrigation at milking stage I_4, and two times irrigation at planting and flowering stages I_5. The sub plots consisted of three dryland wheat cultivars namely Sabalan (V_1), Sardari (V_2) and Azer$_2$ (V_3). Seeds were sown after seed bed preparation. The distance between main plots and sub plots was 2 m and 0.5 m, respectively. Each experimental unit consisted of 4 rows, 3 m in length and 20 cm between rows. Samples were obtained from middle rows. Both years supplemental irrigation was applied as furrow method and the amount of irrigation water was equal for all supplemental irrigation treatments and determined by using a volume counter. Pests, diseases and weeds were controlled satisfactorily using recommended chemicals and management practices. Total N in wheat grain was determined by the micro-Kjeldahl method and converted to protein content [18]. After harvesting spike and seed number were measured within the middle 0.4 m^2 of each plot and recorded per hectare. Grain yield per hectare was obtained by multiplying spike number and seed number per hectare. Seed germination rate was determined by Ellis and Roberts [19] method. The data were subjected to the combined analysis of variance over years and the chi-square test was used to verify homogeneity of variance before combining data. LSD test was used for means separation by using the MSTAT-C statistical software [20].

Results and Discussion

The results obtained from individual analysis of variance at each year and combined analysis of variance across two years revealed significant difference (P<0.01) among different levels of supplementary irrigation, cultivars and their interactions (Tables 1-3). The comparison of treatment means showed that wheat grown with supplementary irrigation had significantly more spikes per m^2, seeds per spike, 1000 grain weight and grain yield compared to control. Also there was a significant variation in studied characteristics in the wheat cultivars. Sardari with one time irrigation at flowering stage produced the highest seed number per spike in both years (Tables 4-6). Also the highest seed yield was obtained from Sardari cultivar with two times irrigation at planting and flowering stages (I_5V_2) as compared to its control treatment (no irrigation) had 71% higher grain yield whereas the lowest yield was obtained from Sabalan without irrigation (I_1V_1). This difference between yield of Sardari and other cultivars was due to their significant difference in spike number per m^2 and 1000 grain weight. In both years Sardari with two times irrigation produced the highest spike number and 1000 grain weight. Sarkar *et al.* [21] also reported variation in grain yield of wheat genotypes grown under different management practices. Applying irrigation at planting stage can result in uniform emergence, tillers development at fall, fertile tillers establishment, increased relative resistance to low temperatures and also increased grain yield due to early emergence [14].

Naser *et al.* [22] reported that early application of irrigation increased grain and straw yields and all yield attributes over control. Tahmasebi Sarvestani *et al.* [9] noted the importance of wheat genotypes under supplemental irrigation and the increase 36% yield of Sabalan compared to other genotypes.

Irrigation at flowering stage increased 1000 grain weight (Tables 4 and 5). Water deficiency during seed filling period can cause significant yield loss [23]. Sufficient water results in increase in spike number per area unit, seed number per spike, 1000 grain weight and grain yield [24, 25].

There was no significant difference in seed viability among different treatments in both years (Tables 1 and 2). As recommendable seed viability range is 90 to 100 %, differences in seed viability among cultivars according to Tables 4 and 5 are not essential.

Table 1. Analysis of variance of evaluated characteristics in dryland wheat cultivars under supplemental irrigation conditions in 2004.

Source of variation	DF	Shoot height	1000 grain weight	Germination rate	Seed N content	Seed germination percentage	Seed number per spike	Spike number	Grain yield
R	2	53.689 $^{n.s}$	11.062 $^{n.s}$	0.000 $^{n.s}$	1.602 $^{n.s}$	0.000 $^{n.s}$	29.39 $^{n.s}$	903.80 **	97441.62 $^{n.s}$
Irrigation (I)	4	47.978 $^{n.s}$	15.488 $^{n.s}$	0.000 $^{n.s}$	0.366 **	0.000 $^{n.s}$	2847.55 **	1407.64**	1576309.64 **
E_1	8	29.44	6.601	0.00002	0.131	0.000	11.75	151.91	16607.51
Cultivar (V)	2	9.356 $^{n.s}$	51.904 **	0.000 $^{n.s}$	0.621 *	0.000 $^{n.s}$	175.15 **	582.06 $^{n.s}$	1301381.75 $^{n.s}$
I*V	8	33.911$^{n.s}$	5.817 $^{n.s}$	0.000 $^{n.s}$	0.247 *	0.000 $^{n.s}$	74.44 **	350.44 $^{n.s}$	205714.81 $^{n.s}$
E_2	20	18.133	3.928	0.00005	0.332	0.000	12.25	262.42	15926.83

* and ** significant at 1% and 5% probability levels, respectively.
n.s Non-significant.

Table 2. Analysis of variance of evaluated characteristics in dryland wheat cultivars under supplemental irrigation conditions in 2005.

Source of variation	DF	Shoot height	1000 grain weight	Germination rate	Seed N content	Seed germination percentage	Seed number per spike	Spike number	Grain yield
R	2	18.422 $^{n.s}$	17.503 $^{n.s}$	0.000 $^{n.s}$	0.428 $^{n.s}$	0.000 $^{n.s}$	28.35 $^{n.s}$	877.22 $^{n.s}$	218422.06 $^{n.s}$
Irrigation (I)	4	17.056 $^{n.s}$	6.581 $^{n.s}$	0.000 $^{n.s}$	0.271 **	0.001 $^{n.s}$	2914.45 **	724.47 $^{n.s}$	1264886.60 **
E_1	8	10.006	5.615	0.000	0.104	0.000	12.01	449.78	12538.71
Cultivar (V)	2	3.289 $^{n.s}$	95.681 **	0.000 $^{n.s}$	0.201 **	0.001 $^{n.s}$	163.20 **	612.70 *	987988.85 **
I*V	8	14.872 $^{n.s}$	6.085 $^{n.s}$	0.000 $^{n.s}$	0.362 **	0.001 $^{n.s}$	71.33 **	329.08 *	203676.17 **
E_2	20	21.089	4.802	0.000	0.246	0.000	11.95	107.93	17248.08

* and ** significant at 1% and 5% probability levels, respectively.
n.s Non-significant.

Table 3. Combined analysis of variance over years (2004 and 2005) for dryland wheat cultivars grain yield under supplemental irrigation conditions.

Source of variation	DF	Grain yield
Year (Y)	1	104789.34 $^{n.s}$
R/Y	4	157931.84**
Irrigation (I)	4	2829696.39 **
I*Y	4	11499.84 $^{n.s}$
E_1	16	14573.10
Cultivar (V)	2	2271990.34 **
I*V	8	404230.95 **
I*V*Y	8	5160.03 $^{n.s}$
E_2	20	15926.83

* and ** significant at 1% and 5% probability levels, respectively.
n.s : Non significant.

Table 4. Effect of supplemental irrigation levels on some characteristics of dryland wheat cultivars in 2004.

Treatments	Seed N content	1000 grain weight	Seed germination percentage	Spike number	Seed number per spike	Grain yield
I_1V_1	14.60 AB	35.57 BCDEF	0.9767 BC	321.3 DE	20 BCD	2045 E
I_1V_2	14.24 AB	36.13 ABCDE	0.9900 A	323.7 CDE	24 AB	2115 E
I_1V_3	15.29 AB	34.53 DEF	0.9733 CD	324.7 CDE	22 BCD	2043 E
I_2V_1	14.13 AB	36.97 ABCD	0.9900 A	346.7 ABCD	20 DC	2847 C
I_2V_2	13.82 BC	38.90 AB	0.9767 BC	349.7 ABC	22 BCD	3177 B
I_2V_3	14.28 AB	32.43 F	0.9900 A	326.0 BCDE	20 BCD	2440 D
I_3V_1	13.45 BC	33.40 EF	0.9900 A	325.0 CDE	23 B	2325 DE
I^3V_2	13.93 BC	37.97 ABC	0.9700 D	325.0 CDE	29 A	3009 BC
I_3V_3	13.84 BC	33.17 EF	0.9800 B	312.7 E	25 AB	2168 DE
I_4V_1	11.97 CD	32.67 F	0.9900 A	317.0 E	22 BCD	2177 DE
I_4V_2	10.56 D	34.63 CDEF	0.9900 A	338.7 ABCDE	25 AB	2938 BC
I_4V_3	11.48 CD	33.60 DEF	0.9900 A	345.0 ABCD	22 BCD	2850 C
I_5V_1	12.04 BC	36.93 ABCD	0.9900 A	337.3 BCDE	23 B	3025 BC
I_5V_2	11.29 BC	39.47 A	0.9800 B	365.7 A	28 A	3712 A
I_5V_3	13.46 BC	34.97 CDEF	0.9900 A	353.3 AB	24 AB	2882 C

Different letters indicate significant difference among treatments.

Table 5. Effect of supplemental irrigation levels on some characteristics of dryland wheat cultivars in 2005.

Treatments	Seed N content	1000 grain weight	Seed germination percentage	Spike number	Seed number per spike	Grain yield
I_1V_1	14.70 AB	33.90 CDE	0.9900 AB	326.0 EFG	20 BCD	2065 CD
I_1V_2	14.56 AB	36.83 BC	0.9867 BC	333.3 CDEFG	23 AB	2056 CD
I_1V_3	15.26 AB	35.30 CDE	0.9900 AB	328.0 DEFG	21 BCD	2012 D
I_2V_1	14.95 AB	36.37 BCD	0.9900 AB	342.7 BCDE	19 CD	2792 B
I_2V_2	13.94 BC	39.10 AB	0.9967 A	352.7 AB	21 BCD	2996 B
I_2V_3	14.30 AB	32.07 E	0.9833 BC	351.7 AB	20 BCD	2335 C
I_3V_1	13.46 BC	34.80 CDE	0.9900 AB	346.7 ABC	22 B	2329 C
I^3V_2	13.35 BC	40.90 A	0.9300 F	336.7 BCDEF	28 A	3004 B
I_3V_3	14.11 BC	33.87 CDE	0.9667 DE	322.3 FG	24 AB	2117 CD
I_4V_1	11.92 CD	32.77 DE	0.9600 E	318.7 G	21 BCD	2133 CD
I_4V_2	10.21 D	36.93 BC	0.9800 C	344.0 BCD	24 AB	2890 B
I_4V_3	11.39 CD	33.00 DE	0.9867 BC	343.3 BCDE	21 BCD	2763 B
I_5V_1	12.58 BC	34.77 CDE	0.9967 A	333.3 CDEFG	22 B	3010 B
I_5V_2	13.89 BC	37.50 ABC	0.9700 D	364.3 A	27 A	3435 A
I_5V_3	13.12 BC	32.97 DE	0.9900 AB	349.0 ABC	23 AB	2793 B

Different letters indicate significant difference among treatments.

Table 6. Grain yield of dryland wheat cultivars at different supplemental irrigation levels (mean of 2004 and 2005).

Treatments	Grain yield
I_1V_1	2054.833 F
I_1V_2	2085.33 F
I_1V_3	2134.27 F
I_2V_1	2819.5 D
I_2V_2	3086.66 B
I_2V_3	2387.833 E
I_3V_1	2326.833 E
I_3V_2	3006.33 BC
I_3V_3	2142.33 F
I_4V_1	2155.00 F
I_4V_2	2914.167 CD
I_4V_3	2806.166 D
I_5V_1	3017.5 BC
I_5V_2	3573.5 A
I_5V_3	2837.33 D

Different letters indicate significant difference among treatments.

Differences among irrigation levels were more significant than those among cultivars with respect to N content (Tables 1 and 2). The highest N content was noted in $Azer_2$ under no irrigation conditions in both years and the lowest one in Sardari with one time irrigation at milking stage (Tables 4 and 5). This result is in agreement with Jamal *et al.*[26] who stated that applying irrigation at end stages of plant growth caused a decrease in grain protein content. There was no significant difference in plant height and seed germination rate among different treatments in both years (Tables 1 and 2).

Conclusions

Sardari cultivation in low rainfall drylands of northwestern of Iran and application of two times irrigation at planting and flowering stages can increase wheat grain yield. Also Sardari had high grain yield with one time irrigation at flowering stage in comparison to its control treatment (no irrigation). Wheat cultivation in semiarid and cold regions takes place in fall and rainfall amount is sufficient to germinate seeds in these regions. Thus, one time irrigation may be applied during water short period of spring, when wheat is at flowering stage.

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