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The effects of supplemental irrigation and N-applications on yield and yield component in two wheat cultivars in Kermanshah condition

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ABSTRACT

In order to effect of supplemental irrigation and nitrogen levels on yield and yield components of two wheat cultivars were performed a experimental at farm of Campus of Agriculture and Natural Resources, Razi University in Kermanshah in 2008-2009. Treatments included supplemental irrigation as the main plot at 4 levels (control (non irrigation) and irrigation during booting, anthesis and grain filling), nitrogen as a sub plot at 4 levels (0, 50, 100 and 150 kg ha^{-1} N net from urea source) and two wheat cultivars "Sardari" and "Cross-Alborz" as sub-sub plots. Experiment was a randomized complete block design with four replications. The result showed the effect of supplementary irrigation, N rate ant cultivar on grain yield were significant. The highest of grain yield obtained in supplemental irrigation at anthesis and booting stages with 362.2 and 352.0 g m^{-2}, respectively. This influenced by increasing the number of spikes per unite area and thousand grain weight, but had not effect on the number of grain per spike. Using of 50 kg ha^{-1} N, with increasing grain number per spike and thousand grain weight produced the highest grain yield (335.0 g m^{-2}). "Cross-Alborz" (337.8 g m^{-2}) relative to "Sardari" (298.2 g m^{-2}) indicated advantage grain yield. "Cross Alborz" in this experiment had the number of spikes m^{-2}, the number of grains per spike, 1000-grain weight, plant height, peduncle length, the contribution of current photosynthesis, the contribution of stem reserves and straw spike reserves more than "Sardari".

Key words: Supplemental irrigation, Nitrogen, wheat cultivar, yield and yield components.

INTRODUCTION

Drought, the most important factor limiting considered for crops successful production in worldwide. This problem, combined with physical and environmental factors that trigger stress in plants and reduce growth. Water stress caused by delay, weaken or/and lack of seedling establishment. Thus, conditions prepare for epidemic diseases, plant pests attack, physiological and biochemical changes. Even in cases of minor, injured and ultimately with reduction growth, damages yield [19, 22, 32, 37, 38].

Effect of supplemental irrigation and nitrogen as two important factors for dry land wheat production has been much studied by local and foreign researchers in different regions with different temperature conditions on earth and other wheat cultivars [23]. Usually in areas with low rainfall, drought has a negative effect on growth and yield of wheat [26]. Fereres and Soriano [15] reported the condition that sufficient water is not available irrigation at the right time and it has considerable impact on wheat yield. Water availability during early vegetative growth of wheat is necessary for proper operation. Water stress reduced number of tillers per unit area and number of spikelets per spike, and the end reduces grain yield [21]. Also water stress after anthesis causes premature aging and reduces transfer of food reserves from vegetative parts to grain [31]. In other words, competition of wheat plants in dry condition is often for soil moistures and allocation of lower assimilate to the roots. Theses causes make less assimilate in grain filling period [30]. In addition to irrigation and soil moisture, nitrogen as a limiting factor has been reported in dryland wheat yield [20, 40]. Irrigation at the appropriate stage (one stage) and especially the amount of nitrogen required increased vegetative growth and photosynthesis to continue for a longer time period, that will produce optimum yield [14, 41]. About 70 to 80 percent of nitrogen in wheat grain, before the anthesis period from vegetative organs is supplied. The transfer of nitrogen from vegetative tissues to grain, is the main source of nitrogen for seed development. On the other hand, dry matter production has been transferred before the anthesis stage, especially when current photosynthesis after anthesis decreases under drought stress (dry conditions), significant share in the grain yields [31]. After anthesis, the reduction in nitrogen supply can significantly reduce grain nitrogen [17, 18].

Wheat yield and mean thousand grain weight by number of grain per unit area is determined. Yield components are heavily influenced by cultivars, environmental condition and resources availability [7, 10, 12, 34]. Ehdaei et al [11] reported that grain growth is dependent on three sources (a) carbohydrates produced after anthesis that transfer directly to grain, (b) carbohydrates produced after anthesis that temporarily stored in the stem and during the grain filling period are transferred and (c) carbohydrates produced before anthesis mainly stored in the stem and during the grain filling period are transferred. As a result, the fate of number of grain per spike, since the beginning of tillering to anthesis, and environmental condition (temperature and nutrition), during the 20 days before anthesis to 10 days after the start of grain filling, influence on grain weight [6]. However, the amount and timing of nitrogen intake is essential for proper yield, and to determine the appropriate time to considered soil characteristics, weather conditions and cultivars.

Nitrogen has been proved that is important in increasing the yield of wheat, but determining the exact amount of nitrogen in the climate data used in the supplemental irrigation requirements and cultivars and their effects on physiological characteristics, carbohydrate and nitrogen remobilization to the grain, the case was investigated.

MATERIALS AND METHODS

This study was performed at Campus of Agriculture and Natural Resources (at latitude 34^0 21′ N and longitude 47^0 9′ E, and at an altitude of 1319 m above sea level) Razi University, Kermanshah province, Iran in 2008-2009. Experiments were designed with split-split plot base on randomized complete block design (RCBD) with four replications. Treatments were Irrigation as the main plot at four levels control (non irrigation) and supplemental irrigation during booting, anthesis and grain filling, nitrogen fertilizer as a sub plot at four levels including 0, 50, 100 and 150 kg ha^{-1} (N net from Urea source) and winter bred wheat as sub-sub plots including two cultivars Sardari and Cross-Alborz. Cultivars are in the wide area under cultivation in region. There is weather specification of temperature and precipitation exam site in 2008-2009 in Table 1. Experimental field was fallow the previous year. The soil was clay loam, with N, P and K, 0.12%, 8 and 370 mg kg^{-1}, respectively. The distances were between the main plot, sub plot and sub-sub plot, 2, 1 and 0.25, respectively. The amount of water (supplemental irrigation) was designed for each plot as a controlled and equal with water pump and water meter for 100 mm [29]. Sowing density was based 350 plant m^{-1}, with 25 cm line spacing and planting was done on November 19. The final harvest was done at a square meter and using its was obtained biological yield and spike and grain yield. Plant height was measured from the soil surface to tip of spikelet at harvest time. Remobilization traits were measured at 10 days after anthesis from 10 main stems from each plot and immediately transported to the laboratory. In the lab, spike, peduncle, penalty meat, other internodes and the leaves were separated from stems and then placed inside a paper bag. These samples were dried for 48 hours at 75 ^{0}C, after drying, the leaf sheath was separated from the stems and then each part was weighed. The same procedure was repeated at maturity. Then using the relations 1, 2 and 3, the attributes associated with remobilization from vegetative organs to grain was calculated [5]. At last data were analyzed with SAS software.

Equation (1) The relative contribution of stem storages in grain yield (%) = Remobilization of stem storage to grain / Grain yield × 100

Equation (2) The relative contribution of spike storages in grain yield (%) = Remobilization of spike straw storage to grain / Grain yield × 100

Equation (3) The relative contribution of current photosynthesis in grain yield (%) = Current photosynthesis / Grain yield × 100

Table 1. Weather data in place of exam

Month	T_{min} (^{0}C)	T_{max} (^{0}C)	Rainfall (mm)
Oct	3.8	32.5	0.0
Nov	-2.2	27.6	100
Dec	-9.9	16.6	53.7
Jan	-13.3	15.1	30.8
Feb	-8.4	17.8	67.1
Mar	-5.2	20.0	16.1
Apr	5.1	21.6	58.5
May	9.4	27.5	7.7
Jun	12.1	32.5	2.9

RESULTS AND DISCUSSION

Results showed that the time of supplemental irrigation had significant effect on total dry matter, grain yield, number of spike m^{-2}, grain weight, harvest index, plant height, grain nitrogen, peduncle length, the contribution of current photosynthesis, the contribution of stem reserves and reserves the spike straw. The effect of nitrogen was significant on grain yield, grain number per spike, grain weight, plant height, N grain, straw, spike length, peduncle and share resources, but had no significant effect on other traits. And differences between cultivars were significant in all traits except total dry matter (Table 2). The results of means comparison of supplemental irrigation time on the total dry matter, grain yield, number of spike, grain weight and harvest index is shown in Table 2.

Effect of different times of supplemental irrigation indicates that the highest total dry matter and grain yield in irrigation at booting and anthesis stages and lowest dry matter obtained in dry conditions (control). These results according to findings oweise et al [33] that supplementary irrigation at heading and grain filling and nitrogen fertilizers were 0, 60 and 120 kg ha^{-1} were studied. It seems, irrigation at anthesis stage survives the pollen and preventing is successful in abortion and pollination. Tinglu et al [16] reported that at anthesis and grain filling such as are green the upper leaves of plants, especially flag leaf and in adequate moisture conditions (supplemental irrigation) can have more photosynthesis and more material transfer into the grain filling and can be increase yield.

Also in this experiment, maximum number of spikes per square meter and grain weight was obtained at supplemental irrigation during the anthesis and booting stages, respectively. Supplementary irrigation at anthesis increased thousand grains weight (11.0 g) compared to the control treatment (rainfed).

The results mean comparison of nitrogen fertilizer on grain yield, grain number per spike and grain weight is shown in Table 3. Grain yield have increased with increasing nitrogen to 50 kg ha^{-1}, but at higher values of this amount, has declined yield. Reports of various investigations show the application N in rainfed conditions than not to use it has led increase wheat yield, but its amount well it is not known. For example, Anagholi et al [2] with the use of 90 kg ha^{-1}, Tavakoli and Oweis [4] and Oweis et al [33], with the use of at 60 kg ha^{-1}, Sandhu and Sidhu [24] by applying 80 kg ha^{-1} and flourish, Shekoofa and Emam [3] with the use of 100 kg ha^{-1} obtained the maximum grain yield under rainfed condition.

Table 2. Effect of supplemental irrigation time, nitrogen and cultivar on yield and yield components of wheat

treatments		Dry matter (g m^{-2})	Grain yield (g m^{-2})	Number of spike m^{2}	Grain number per pike	Thousand grain weight (g)	Harvest index (%)
Supplemental irrigation	Control	840.40^{c}	272.40^{b}	425.40^{c}	22.46^{a}	25.83^{d}	32.21^{a}
	Booting	1172.00^{a}	353.20^{a}	588.60^{a}	22.02^{a}	30.04^{c}	30.17^{a}
	Anthesis	1113.00^{a}	361.00^{a}	556.50^{b}	22.76^{a}	36.51^{a}	32.29^{a}
	Grain filling	966.70^{a}	283.20^{b}	457.50^{b}	21.20^{a}	34.33^{b}	29.58^{a}
	p value	**	**	**	ns	**	ns
Nitrogen (kg ha^{-1})	0	1035.42^{a}	322.90^{b}	486.97^{a}	21.99^{a}	31.78^{a}	31.25^{a}
	50	1022.06^{a}	335.00^{a}	514.13^{a}	23.40^{a}	31.69^{a}	33.00^{a}
	100	1010.75^{a}	301.90^{c}	516.97^{a}	22.85^{a}	32.69^{a}	30.00^{a}
	150	1024.44^{a}	310.30^{c}	509.91^{a}	20.21^{b}	30.81^{b}	30.00^{a}
	p value	ns	*	ns	**	**	ns
Wheat cultivars	Sardari	1001.18^{a}	296.25^{b}	517.36^{a}	17.19^{b}	33.59^{a}	29.56^{b}
	Cross-Alborz	1044.28^{a}	337.80^{a}	495.13^{b}	26.57^{a}	29.39^{b}	32.56^{a}
	p value	ns	**	*	**	**	**

*ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.*
Within each column (between two horizontal lines), mean followed by a different letter are significantly different at 5% level (DMRT).

In this experiment seems, the crop needs to nitrogen supplied at 50 kg ha^{-1} and more uses nitrogen according to local environmental conditions has caused loss grain yield. The total dry matter in the Cross-Alborz (1044.2 g m^{-2}) was the more Sardari (1001.0 g m^{-2}). Probably, more total dry matter in the Cross-Alborz is related to the optimal of environmental factors and efficiency of dry matter production, which could store more carbohydrates. Also Cross-Alborz in grain yield, ear number per square meter, grain number per spike and harvest index was superior to Sardari cultivar. This cultivar was higher harvest index, in other words, more photosynthetic material has been assigned to the grain, that this is also mentioned by other researchers [25, 36].

Table 3. Effect of supplemental irrigation time, nitrogen and cultivar on studied traits

Treatments		Plant height (cm)	N grain (%)	Peduncle height (cm)	Current photosynthesis (%)	Stem storage (%)	Spike storage (%)
Supplemental irrigation	Control	63.51^{b}	2.35^{a}	21.48^{b}	0.37^{b}	0.40^{bc}	0.23^{a}
	Booting	82.37^{a}	2.18^{b}	32.16^{a}	0.33^{b}	0.47^{b}	0.20^{ab}
	Anthesis	60.86^{bc}	2.04^{c}	19.78^{bc}	0.56^{a}	0.33^{c}	0.11^{c}
	Grain filling	57.69^{c}	2.09^{c}	17.68^{c}	0.24^{c}	0.60^{a}	0.18^{b}
	p value	**	**	**	**	**	**
Nitrogen (kg ha^{-1})	0	63.80^{b}	2.15^{b}	21.72^{a}	0.40^{a}	0.42^{a}	0.17^{b}
	50	69.06^{a}	2.16^{b}	23.83^{a}	0.39^{a}	0.44^{a}	0.19^{b}
	100	67.06^{ab}	2.12^{b}	22.38^{a}	0.28^{a}	0.47^{a}	0.25^{a}
	150	64.50^{b}	2.21^{a}	23.19^{a}	0.42^{a}	0.47^{a}	0.11^{c}
	p value	**	**	ns	ns	ns	**
Wheat cultivars	Sardari	62.45^{b}	2.16^{a}	21.82^{b}	0.32^{b}	0.53^{a}	0.16^{a}
	Cross-Alborz	69.77^{a}	2.16^{a}	23.74^{a}	0.43^{a}	0.37^{a}	0.20^{a}
	p value	**	ns	**	*	ns	ns

*ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.*
Within each column (between two horizontal lines), mean followed by a different letter are significantly different at 5% level (DMRT).

The results of means comparison of supplemental irrigation time on plant height, grain nitrogen, peduncle length, the contribution of current photosynthesis, the contribution of stem reserves and reserves the straw spike has come table 3. Maximum plant height (82.3 cm) and peduncle length was obtained in irrigation at booting stage, that were in accordance with the results of Emam et al [39] and Alpheredo et al [1]. The highest amount of N-grain was in supplemental irrigation treatments and N fertilizer, in control (2.35%) and 150 kg ha^{-1} N (2.21%), respectively.

Contribution of current photosynthesis with the supplementary irrigation at anthesis was higher than (56%) in other stages, that indicating water supply at the time the plant needs to water. With the supplementary irrigation at anthesis, the current photosynthesis was 32 percent more than grain filling stage and 23 percent more than in the booting stage. Perhaps, could be the reason supplied with the irrigation at the appropriate time as which has creates favorable conditions for current photosynthesis. The highest proportion of stem reserves was obtained irrigation at the grain filling stage and more contribution to spike straw reserves in control. Reserves of vegetative organs, especially stems in existing stresses in the grain filling period are an important source for grain growth [5].

According to the results in table 3, in the control treatments (no irrigation) were contribution of stem reserves in grain filling (40%) most of the contribution of current photosynthesis (37%) and contribution to spike straw reserves (23%), respectively. Irrigation at the booting stage were contribution of stem reserves in grain filling (47%) most of the contribution of current photosynthesis (33%) and contribution to spike straw reserves (20%), respectively. Irrigation treatments, by providing suitable for dry matter production are increases in dry matter accumulation in vegetative organs [28].

The results of means comparison of interaction supplemental irrigation timing and amounts of nitrogen fertilizer on total dry matter, grain yield, grain number per spike, seed weight, plant height and grain nitrogen content Is shown in table 4. Effect of treatments on yield and yield components was different. So that, the highest total dry matter was obtained in supplemental irrigation and nitrogen in the booting stage amount of 100 kg ha^{-1}. The results showed that supplementary irrigation during booting and anthsis and applying N-fertilizer has increased the total dry matter. It is necessary to mention that the importance and effects of water is more than N-fertilizer, because N is cheaper and can reach further. Numbers of grain per spike was obtained at supplemental irrigation during the booting and use 50 kg ha^{-1} of nitrogen.

Sinclair and Jamiesen [35] proved the yield and especially grain number due to N-supply during the growing season is severely limited. But, the highest grain yield and 1000-grain weight was obtained at supplemental irrigation during anthesis and consumption of 50 kg ha^{-1} N, respectively. The highest percentage of N grain was the no irrigation and nitrogen fertilizer 150 kg ha^{-1}. It seems that in rainfed conditions because is yield lower, transfer of carbohydrates is reduced to seeds and the percentage of nitrogen transfer to grain is higher. Mean comparison of interaction of supplemental irrigation and wheat cultivar on spike per square meter, grain weight and N grain content is shown in table 5. Maximum number of spikes m^{-1} was obtained in irrigation at booting stage in the Cross-Alborz and Sardari. It seems that irrigation at this stage compared to the final stages such as anthesis and grain filling stages more help to survival tillers of produced. Although the, the highest thousands grain weight was obtained in Sardari and irrigation at anthesis. Highest percentage of N grain was supplemental irrigation at anthesis stage and Sardari (2.36%).

Table 4. Mean comparison of supplemental irrigation time and nitrogen fertilizer on studied traits

Supplemental irrigation time	Nitrogen (kg ha^{-1})	Dry matter (g m^2)	Grain yield (g m^2)	Grain number per spike	Thousand grain weight (g)	N grain (%)	Plant height (cm)
Control	0	830.0^{g}	271.5^{ef}	20.9	25.7^{f}	2.27	58.28^{de}
	50	838.3^{g}	283.1^{def}	23.2	26.3^{f}	2.34	64.67^{bcd}
	100	841.7^{g}	286.8^{def}	23.5	26.5^{f}	2.34	67.18^{bc}
	150	851.7^{fg}	246.4^{f}	22.1	25.6^{f}	2.42	63.92^{bcd}
Booting	0	1214.0^{a}	376.8^{ab}	23.4	32.3^{d}	2.30	83.70^{a}
	50	1150.0^{ab}	344.3^{bcd}	25.5	29.5^{e}	2.09	84.92^{a}
	100	1220.0^{a}	332.9^{b-e}	21.7	29.0^{e}	1.95	82.37^{a}
	150	1093.0^{a-d}	359.1^{abc}	17.3	29.3^{e}	2.37	78.50^{a}
Anthesis	0	1125.0^{abc}	376.8^{ab}	21.8	34.4^{bc}	1.91	58.05^{de}
	50	1195.0^{a}	424.4^{a}	21.4	38.4^{a}	2.01	69.60^{b}
	100	1000.0^{cde}	284.8^{def}	23.4	38.0^{a}	2.21	58.07^{de}
	150	1133.0^{abc}	358.0^{abc}	23.3	34.6^{bc}	2.02	57.73^{de}
Grain filling	0	961.0^{d-g}	265.8^{ef}	21.7	34.6^{bc}	2.12	55.17^{e}
	50	905.0^{efg}	290.3^{def}	22.8	33.6^{cd}	2.21	57.07^{de}
	100	981.5^{def}	300.3^{c-f}	22.0	35.8^{b}	1.97	60.67^{cde}
	150	1018.5^{b-e}	276.5^{def}	17.5	33.6^{cd}	2.06	57.85^{de}
	p value	**	**	ns	*	ns	*

*ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.*
Within each column, mean followed by a different letter are significantly different at 5% level (DMRT).

The mean comparison of interaction of wheat cultivars and N fertilizer on the total dry weight, number of grains per spike, grain weight and grain nitrogen content is shown in table 6. Applying N fertilizer in both cultivars is not appreciably change the amount of dry matter. Cross-Alborz in all values of N, compared to Sardari was a greater number of grains per spike but in both cultivars was obtained the highest number of grains per spike in the 50 kg ha^{-1} N. Gap in grain production in Cross-Alborz and Sardari due to greater ability Cross-Alborz in production the number of spike and grain number per unit area. Sardari the thousand grain weight was higher. It could be due to produced less number grain. Because increasing the number of grain is produced the grains that further away than the spike center, and this makes the thousands grain weight will be reduced [8, 9].

Table 5. Interaction between supplemental irrigation time and wheat cultivars on number of spike m^{-2}, thousand grain weight and N grain

Supplemental irrigation time	Cultivar	Number of spike m^{-2}	Thousand grain weight (g)	N Grain (%)
Control	Sardari	419.1^{d}	28.4^{e}	2.33^{a}
	Cross-Alborz	431.9^{d}	23.3^{g}	2.21^{b}
Booting	Sardari	582.9^{a}	32.7^{d}	2.10^{cd}
	Cross-Alborz	593.2^{a}	27.3^{f}	2.02^{de}
Anthesis	Sardari	579.5^{a}	38.7^{a}	2.36^{a}
	Cross-Alborz	533.4^{b}	34.3^{bc}	2.15^{bc}
Grain filling	Sardari	490.1^{c}	35.1^{b}	2.00^{e}
	Cross-Alborz	425.9^{d}	33.6^{cd}	2.15^{bc}
	p value	**	**	**

*ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.*
Within each column, mean followed by a different letter are significantly different at 5% level (DMRT).

Although, final grain number and grain weight in separate stages of plant growth are determined, the research results show that there is an inverse relationship between these two components [10, 13, 27]. However, thousands grain weight of Sardari increased with 50 to 100 kg ha^{-1} N. The highest percentage of N grain was obtained in Sardari with the nitrogen fertilizer 150 kg ha^{-1}. Sardari, because of lower yield and also due to higher genetic potential and absorption index has transfer efficiency of nitrogen to increase yield. Interaction of time of supplemental irrigation, wheat cultivar and N fertilizer was significant on the number of grains per spike, grain weight and grain nitrogen content.

As can be seen, Cross-Alborz in 50 kg ha^{-1} N supplementary irrigation during the anthesis was the most number of grains per spike. Sardari in terms of grain weight at 100 kg ha^{-1} N and supplemental irrigation during booting had the highest values. Highest percentage of N grain in the control treatment and Sardari and N fertilizer was obtained 150 kg ha^{-1}.

Table 6. Interaction between of cultivar and nitrogen fertilizer on dry matter, grain number per spike, thousand grain weight and N grain

Cultivar	Nitrogen (kg ha^{-1})	Dry matter (g m^{-2})	Grain number per spike	Thousand grain weight (g)	N grain (%)
Sardari	0	1061.0^{a}	17.39^{c}	33.25^{b}	2.11^{cd}
	50	1017.0^{ab}	18.08^{c}	34.92^{a}	2.14^{bcd}
	100	935.8^{b}	17.80^{c}	34.67^{a}	2.16^{abc}
	150	935.2^{ab}	17.26^{c}	32.08^{c}	2.33^{a}
Cross-Alborz	0	1010.0^{ab}	26.59^{a}	30.58^{d}	2.20^{ab}
	50	1028.0^{ab}	28.72^{a}	28.83^{e}	2.18^{abc}
	100	1086.0^{a}	27.90^{a}	29.67^{de}	2.10^{d}
	150	1054.0^{ab}	23.17^{b}	29.42^{e}	2.20^{ab}
	p value	*	*	**	*

*ns, * and ** : Not significant, significant at 5% and 1% probability levels, respectively.*
Within each column, mean followed by a different letter are significantly different at 5% level (DMRT).

CONCLUSION

According to the results of the present work, the specific conditions of precipitation (328.4 mm), also with regard to temperature and soil conditions, conclude that supplemental irrigation during anthesis and/or booting sages is better than of grain filling period and even before this stage (during the stem elongation), increased of grain yield. Thus increasing the number of spikes per unit area (most effective) and thousand grain weight (less impact), respectively. 50 kg ha^{-1} of nitrogen fertilizer also increased grain yield with increasing the number of grains per spike, than other treatments. Both Cross-Alborz and Sardari are especially rainfed area and in this experiment there was no difference in yield, but the reaction Cross-Alborz in supplemental irrigation condition was the fertilizer higher than the Sardari, although Sardari cultivar in rainfed conditions (control) had a better yield.

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