American-Eurasian J. Agric. & Environ. Sci., 7 (6): 684-688, 2010
ISSN 1818-6769
© IDOSI Publications, 2010

Yield and Yield Components of Dry Land Wheat Cultivars as Influenced by Supplementary Irrigation at Different Growth Stages

[1]*Rahim Naseri,* [1]*Abbas Soleimanifard and* [2]*Reza Soleimani*

[1]Ilam University, Ilam, Iran
[2]Agriculture and Natural Resources Research Center, Ilam, Iran

Abstract: In order to study the response of grain yield and yield components of rainfed wheat cultivars under supplementary irrigation, an experiment was conducted as split plot using randomized complete block design in 2008-2009 in Ilam, Iran. The main plots were level of different irrigation (Check (witness), stem elongation, flowering and grain filling) and subplots were five cultivars (Zagros, Sablan, Lin B, Chenab and Koohdasht). The results showed that different level of irrigation was affected on grain yield and yield components. Irrigation in all growth stages increased the grain yield and its components. So, increase of grain yield by supplementary irrigation at stem elongation stage compared with control treatment was up to 60 percent. Protein content was affect by different levels of irrigation. Grain yield and its components were significantly different among cultivars. Zagros and Chenab cultivars produced the highest (1778 kg/ha) and the least grain yield (1384 kg/ha), respectively.

Key words: Wheat · Dry · Supplementary irrigation · Grain yield

INTRODUCTION

Current estimates indicate that 25% of the world agricultural lands are affected by water stress. Iran, with an annual 240 mm of rainfall, is classified as a dry region of the word [1]. Wheat (*Triticum aestivum*, L.) is one of the main cereal crops, cultivated to demands of the population for human feeding [2]. Winter wheat (*Triticum aestivum* L.) is the most important food grain produced in Iran with cultivated area 6 million ha [3]. Drought stress affects on plant growth, tillage, photosynthesis, grain number and size [4]. Supplementary irrigation can result in permanent and satisfactory yield in rainfed wheat farms. Because of increasing dryness and temperature in central and western areas of Iran, cultivated wheat in this regions are exposed to water stress. So, non-irrigation resulted in a decrease in the grain yield in the dry land cultivars [5]. Ahmadi and Bahrani [6] reported that seed yield reduction by water stress during stem elongation, flowering and pod development of rapeseed were mostly associated with the reduction of pod per plant. Zhaohui Wang *et al.* [7] indicated that by using supplemental irrigation at grain-filling stage increased grain yield indicated that wheat at tillering, stem elongation and grain-filling stages was more sensitive to water deficit than at dormant stage. Stress effects can be avoided or minimized by management practices that increase soil water storage at planting or by application of irrigation water [8]. Li *et al.* [9] showed that the irrigation schedules as pre-sowing irrigation + irrigation at jointing or booting stage and pre-sowing irrigation + irrigations at jointing and flowering stages were recommended for winter wheat production in the North China Plain. Also at anthesis, the lowest number of kernel per spike was obtained in moisture stress conditions [10]. Moisture stress is known to reduce biomass, grains per spike and grain size at any stag. So, the effect of the moisture stress was depended on its intensity and length of moisture stress [11]. Singh *et al.* [12] found that the yield and yield components of wheat were decreased with decrease of irrigation water amount as well as the quality.

The objective of this experiment was to determine the variability of grain yield and yield components of wheat as affected by supplementary irrigation.

MATERIALS AND METHODS

Field experiment was carried out during growing season of 2008-2009 in west of Iran (37*16′ N, 55* 12′ E; elevation 37.2m), with mean annual precipitation and

Corresponding Author: Reza Soleimani, Department of Soil Science, Agriculture and Natural Resources Research Center, Ilam, Iran, Tell: +98 8413341251

Table 1: Mean rainfall amounts in Ilam, Iran

	Rainfall(mm)	
Months	1999-2007	2008-2900
Sep-Oct	2.06	18.7
Oct-Nov	8.50	0.8
Nov-Dec	57.50	55.6
Dec-Jan	79.50	59.9
Jan-Feb	93.60	42.7
Feb-Mar	143.40	43.9
Mar-Apr	55.90	18.0
May-Apr	69.20	7.0
May-Jun	28.80	5.7
Jun-Jul	1.02	0.0
Jul-Aug	0.33	0.0
Aug-Sep	0.10	0.0
Total	539.10	252.3

relative humidity of 252.3 mm and 65%, respectively (Table 1). The field soil was silt loam. Electrical conductivity and pH were 0.73 dS m^{-1} and 7.2, respectively. Sown was on November 2008 at seeding rate of 250 kg ha^{-1}. The experimental design was as split plots, arranged in randomized complete block design with three replications. The main plots were as levels of irrigation application (Control, irrigation during stem elongation, Flowering and grain filling stages) and five cultivars (Zagros, Sabalan, Line B, Chenab and Koohdasht) were as subplots. Vegetative growth characteristic such as number of spike per m^2, number of spikelet per spike, number of grain per spike, 1000-grain weight, fertile tillers, grain yield and protein percentage were measured in experimental plots. The data were analyzed statistically by SAS and MSTATC programs and the data means were compared by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Results of variance analysis showed that there is significant different at $p<1\%$ under supplementary irrigation (Table 2). Irrigation treatment in early growth stages induced increasing grain yield compared to control. The maximum increase of grain yield was related to supplementary irrigation in stem elongation stage. Mean grain yield was 1869 kg/ha and yield increase was 60% compared to control (with grain yield of 1163 kg/ha). Wheat stem elongation stage had more sensitivity than other stages. Stem elongation stage is beginning of rapid plant growth. Irrigation during stem elongation stage induced grain yield increase compared to other treatments. Adequate water is very important for increasing number of spikelet and number of floret in spikelet. In this study, number of spike/m^2 was 243.06 that increasing value was 34 spike/m^2 in comparison with control (Table 3). Also, it is showed that irrigation time is important for development of plant in different plant growth stages such as beginning of stem elongation stage. Day and Intapal [13] suggested that water stress during beginning of stem elongation decreased number of spikes and 1000-grain weight. Zhang and Oweis [14] reported that the sensitive growth stages of wheat to soil water deficit were from stem elongation to booting stages, followed by anthesis and milking. Stone and Nicholas [15] indicated that Spike density and number of kernel per spike were affected similarly by water stress treatments.

Adequate moisture during stem elongation, grains filling and late growing stages has important role for increasing wheat yield. Rana *et al.* [16] and Kimutro *et al.* [17] found that water stress during tillering or booting stages significantly affected the formation of tillers in wheat. In these stages, number of spike/m^2 decreased due water stress conditions. But, supplementary irrigation during flowering and grain filling stages hadn't effect on number of spike/m^2 (Table 2). Water stress during reproductive growth stage can result a drastic change in grain yield. Irrigation during primary stages in dry cultivars can affect productive tillers. Jones *et al.*, (1985) showed that water deficit during flowering stage affected grain number, while water deficit after anthesis reduced grain size [18]. Sinaki *et al.* [19] found that the highest rapeseed yield reduction was obtained when water stress occurred at flowering and pod development stages. Also, number of grains and flowers were decreased when wheat plants was exposed to water stress. On other hand, transferring materials from phloem to other parts of plants is depended on both plant photosynthesis and metabolism [20]. Also, water deficit reduced photosynthesis and consumption of photosynthetic materials in growing leaves [21]. The reduction of water potential induced decreasing net assimilation in the result of grain filling decrease under water deficit conditions [22]. Irrigation during flowering stage increased number of grains per spike, because irrigation after this stage or during grain filling stage has effect on survival of florets per spikelet.

In dry treatment, water deficit affect on florets un-productivity and number of grain. Irrigation during grain filling increased grain yield due to increasing 1000-grain weight up to 37 g. During grains filling, all plant components act as sink and all photosynthetic materials

Table 2: Results of variance analysis of grain yield and yield components of wheat

MS								
S.O.V	df	Grain yield	Number of spikes/m^2	Number of spikelet per spike	Grains per spike	1000-grain weight	Fertility of tillering	Protein percent
Replication	2	110075.4	442.8	0.04	177.3	8.5	0.13	3.3
Irrigation	3	1283468.1**	4055.4**	56.5**	598.9**	281.1**	14.63**	17.2**
Error a	6	11963.1	70	0.05	12.2	7.7	0.11	0.39
Cultivars	4	259526.6**	798.3**	0.36**	39.7**	62.6**	1.9**	039ns
Interaction	12	19330ns	105.98**	0.30**	96.6**	7.2ns	0.78**	0.36ns
Error b	32	15089.1	21.8	0.03	6.1	5.2	0.13	0.16
CV%		7.85	2.4	1.63	10.51	7.4	9.8	3.4

ns, * and ** showed non-significant and significant in 5% and 1%, respectively

Table 3: Mean comparison of grain yield and yield components of wheat as affected by irrigation treatments

Irrigation	Grain yield (kg/ha)	Number of spikes/m^2	Number of spikelet per spike	Grains per spike	1000-grain weight	Fertile of tillering	Protein percent
Non irrigation	1163c	208.3b	8.8c	18.4c	26.6d	2.9c	13.1a
Irrigation during stem elongation stage	1868a	243.1a	13.4a	20.6b	28.8c	5.1a	11.7b
Irrigation during flowering stage	1641b	211.6b	12.02b	32.8a	30.6b	3.6b	11.5b
Irrigation during grain filling stage	1582b	210.5b	11.8b	21.2b	36.7a	3.2b	10.6c

The same letter (letters) showed non differences between treatments

Table 4: Mean comparison of grain yield and yield components of wheat cultivars

Cultivars	Grains yield (kg/ha)	Number of spikes/m^2	Number of spikelet per spike	1000-grain weight (g)	Grains per spike	Fertile of tillering	Protein percent(%)
Zagros	1778a	238.1a	12.5a	23.08a	21.6c	4.3a	11.7a
Sabalan	1599b	218.1b	12.2b	31.5a	21.5c	3.6bc	11.6a
Chenab	1384c	212.8c	10.4c	28.4b	26.5a	3.2c	12.04a
Koohdasht	1477bc	210.9c	10.2c	28.1b	24.3ab	3.5c	11.6a
Line B	1580b	218.3b	12.07b	32.4a	22.3bc	4ab	11.7a

The same letter (letters) showed non differences between treatments

Table 5: Mean comparison of grain yield and yield components as affected by irrigation and wheat cultivars

Treatment		Grains yield (kg/ha)	Number of spikes/m^2	Number of spikelet per spike	Grains per spike	1000-seed weight (g)	Fertile of tillering	Protein percent(%)
	Zagros	1350i	219de	9.1i	18f	28.3fghi	3.2hi	13b
	Sabalan	1167j	206.7f	9j	18.6ef	28ghi	2j	12.8b
Non irrigation	Chenab	1033j	206.7f	8.1k	19ef	24.3i	3i	14a
	Koohdasht	1083j	203.3f	8k	18.3ef	24.6i	3i	12.9b
	Line B	1183j	206.f	9j	18.3ef	28ghi	3.4gh	13.2b
	Zagros	2245a	265.3a	14.5a	20def	30efgh	6.3a	11.6c
	Sabalan	1983b	245b	14.1b	20.6def	30efgh	5.8b	11.6c
Irrigation during stem elongation stage	Chenab	1583efgh	225cd	12.4e	21.3def	26.3hi	4ef	11.8c
	Koohdasht	1680def	230c	12.07f	20.3def	26.3hi	4.5d	11.6c
	Line B	1850bc	250b	13.9b	20.6def	31.3defg	5.1c	11.8c
	Zagros	1790cd	221.7cd	13c	27c	31.3efg	4.1e	11.3c
	Sabalan	1650defg	211.3ef	13c	26.6c	32.3cdef	3.6i	11.6c
Irrigation during flowering stage	Chenab	1483ghi	209.7f	10.7g	43a	27.6ghi	3i	11.3c
	Koohdasht	1593efgh	206f	10.5gh	38.6b	28.3fghi	3.5g	11.6c
	Line B	1687cdef	209.3f	12.8cd	29c	33.3defg	3.9f	11.7c
	Zagros	1727cde	221cd	12.8cd	21.6de	42.6a	3.4g	11cd
	Sabalan	1597efgh	2093f	12.8cd	20.3def	35.6bc	3.06i	10.5ed
Irrigation during grain filling stage	Chenab	1437hi	209.3f	10.5gh	23d	35.3bcd	3.06i	11cd
	Koohdasht	1550fgh	204.3f	10.3h	20def	33bcd	3.03i	10.1e
	Line B	1600efgh	208f	12.6de	21.3def	37b	3.5f	10.3de

The same letter (letters) showed non differences between treatments

Table 6: Matrix relations among grain yield and yield components of wheat

	Grains yield	Number of spikes/m^2	Number of spikelet per spike	Grains per spike	1000-grain weight	Fertile of tillering	Protein percent
Grains yield	1						
Number of spikes/m^2	0.75**	1					
Number of spikelet per spike	0.85**	0.69**	1				
Grains per spike	0.10^{ns}	-0.12^{ns}	0.15ns	1			
1000-grain weight	0.32*	-0.011^{ns}	0.53**	-0.03^{ns}	1		
Fertile of tillering	0.65**	0.80**	0.70**			1	
Protein percent	-0.45**	0.02^{ns}	-0.52**	-0.13^{ns}	-0.60**	-0.12ns	1

ns, * and ** showed non-significant and significant in 5% and 1%, respectively.

transfer to grain, thus water deficit caused small and thin grains. Grain weight depends on speed and time of grain filling. Existing environmental stress such as water deficit reduced speed and time of grain filling. Guttieri *et al.* [23] and Zhang *et al.* [24] found that drought stress reduced grain yield due to the reduction in kernel growth rate. Altenbach *et al.* [25] demonstrated that kernel size and yield reduction were due to the shortening of the duration of grain filling. Solomon *et al.* [26] and Ozturk and Aydin [27] also found that grain yield was reduced by 79.7 and 65.5% when water stress was occurred either at earlier stages or at grain filling stage. Among investigated cultivars, Zagros cultivar had the maximum grain yield (1778 kg/ha) and Chenab cultivar had the minimum grain yield (1384 kg/ha) (Table 3). This study determined that Zagros cultivar had better position both in number of spike/m^2 and 1000-grain weight than other cultivars. In attention to these results and existing positive correlation of grain yield with number of spikes/m^2 and 1000-grain weight, we can concluded that suitable vegetable growth increased the grain yield in dry wheat cultivars. Different levels of irrigation had different effect on protein percentage. Overall, water stress induced increasing grain protein percentage. The increase in grain protein was likely a function of yield reduction induced by water stress [28]. Chenab cultivar under non-irrigation treatment and Koohdasht under irrigation treatment during grain filling stage had the most and the least protein percentage, respectively (Table 5). Finally, this study showed that supplemental irrigation increased grain yield of dry wheat in each growth stage. Water deficit during the critical period, resulted in a reduction in shoot growth and yield [29]. Each growth stages have variable sensitivity response to water deficit and this can affect grain yield and yield components of wheat. Irrigation during beginning of stem elongation induced the highest number of spikes/m^2. Irrigation during flowering stage inhibited florets un-productivity. Irrigation during grain filling stage resulted in an increase in 1000-grain weight.

CONCLUSION

Supplemental irrigation in all growth stages increased grain yield and yield components and also during stem elongation stage compared with control. Grain yield was increased significantly. Protein content was affected by different levels of irrigation. The differences of grain yield and its components among cultivars were significant. Zagros and Chenab cultivars produced the highest (1778 kg/ha) and the least grain yield (1384 kg/ha), respectively. It is concluded that supplementary irrigation during stem elongation stage has an important role on variability of grain yield and yields components of wheat in western Iran.

REFERENCES

1. Tahmasebi, A., 2009. Indigenous knowledge for water management in Iran. Intl. J. Environ. Studies, 66: 317-325.
2. Mesbah, E.A.M., 2009. Effect of irrigation regimes and foliar spraying of potassium on yield, yield components and water use efficiency of wheat *(Triticum aestivum*, L.) in sandy soils. World J. Agric. Sci., 5: 662-669.
3. Fallahi, H.A., A. Nasseri and A. Siadat, 2008. Wheat yield components are positively influenced by nitrogen application under moisture deficit environments. Intl. J. Agric. Biol., 10: 673-676.
4. Tavakoli, A.R. and T.Y. Owise, 2004. The role of supplemental irrigation and nitrogen in producing bread wheat in the highlands of Iran. Agricultural Water Management 65: 225-236.
5. Han, H., Z. Li, T. Ning, X. Zhang, Y. Shang and M. Bai, 2008. Radiation use efficiency and yield of winter wheat under deficit irrigation in North China. Plant and Soil Environ., 54: 313-319.

6. Ahmadi, M. and M.J. Bahrani, 2009. Yield and yield components of rapeseed as influence by water stress at different growth stage and nitrogen levels. J. Agric. Environ. Sci., 5: 755-761.
7. Zhaohui, W., S. Li, C.L. Vera and S.S. Malhi, 2005. Deficit and Supplemental Irrigation on Winter Wheat Growth, Grain Yield and Quality, Nutrient Uptake and Residual Mineral Nitrogen in Soil. Communications in Soil Science and Plant Analysis 36: 1405-1419.
8. Musick, J.T., O.R. Jones, B.A. Stewart and D.A. Dusek, 1994. Water-Yield Relationships for Irrigated and Dryland Wheat in the U.S. Southern Plains. Agronomy Journal 86: 980-986.
9. Li, J., S. Inanaga, Z. Li. and A. E. Eneji, 2005. Optimizing irrigation scheduling for winter wheat in the North China Plain. Agricultural Water Management 76: 8-23
10. Gholami, A. and A.P. Asadollahi, 2008. Improving wheat grain yield under water stress by stem hydrocarbon reserve utilization. Pakistan Journal of Biological Science 11: 2484-2489.
11. Bukhat, N.M. 2005. Studies in yield and yield associated traits of wheat (Triticum aestivum L.) genotypes under drought conditions. M. Sc. Thesis submitted to Department of Agronomy, Sindh Agriculture University Tandojam and Pakistan.
12. Singh, O. 1991. Influence of water deficit on phonology, growth and dry matter allocation in chickpea. Field Crops Research 28: 1-15.
13. Day, A. D. and S. Interlay, 1970. Some effects of soil moisture in the growth of wheat (*Triticum aestivum* L *Ethel*). Agronomy Journal 62: 27-32.
14. Zhang, H. and T. Oweis, 1999. Water-yield relation and optimal irrigation scheduling of wheat in the Mediterranean region. Agric. Water Management, 38: 195-211.
15. Stone, P.J. and M.E. Nicholas, 1995. Comparison of sudden heat stress with gradual exposure to high temperature during grain filling in two wheat varieties differing in heat tolerance. I. Grain growth. Australian J. Plant Physiol., 22: 935-944.
16. Rana, V., S.C. Sharma and G.S. Sethi, 1999. Comparative estimates of genetic variation in wheat under normal and drought conditions. J. Hill Res., 12: 92-94.
17. Kimurto, P., K. Kinyua and M.J. Nijoroge, 2003. Response of bread wheat genotypes to drought stimulation under a mobile rain shelter in Kenya. African Crop Science J., 11: 225-234.
18. Jones, R.J., J. Rooster and S. Outer, 1985. Thermal environment during endosperm cell division and grain filling in maize. Effects on kernel growth and development *in Vitro*. Crop Science, 25: 762-769.
19. Sinaki, J.M., E.M. Heravan, A.H.S. Rad, G. Noormohammadi and G. Zarei, 2008. The effects of water deficit during growth stages of canola (*Brassica napus* L.). American-Eurasian J. Agric. Environ. Sci., 2: 417-422.
20. Gamalei, Y.V., 2007. The role of mesophyll cell tonoplast in determining the route of phloem loading. Russian J. plant Physiol., 54: 1-9.
21. Lawlor, D.W., 2002. Limitation to photosynthesis in water-stressed leaves: stomata *vs.* metabolism and the role of ATP. Annals of Botany, 89: 871-885.
22. Gooding, M.J., R.H. Ellis, P.R. Shewry and J.D. Schofield, 2003. Effect of restricted water availability and increased temperature on the grain filling, drying and quality of winter wheat. J. Cereal Sci., 37: 295-309.
23. Guttieri, M.J., J.C. Stark, K. O'Brien and E. Souza, 2001. Relative sensitivity of spring wheat grain yield and quality parameters to moisture deficit. Crop Science, 41: 327-335.
24. Zhang, J., X. Sui, B. Li, J. Li and D. Zhou, 1998. An improved water use efficiency for winter wheat grown under reduced irrigation. Field Crops Research, 59: 91-98.
25. Altenbach, S.B., F.M. Dupont, K.M. Kothari, R. Chan, E.L. Johnson and D. Lieu, 2003. Temperature, water and fertilizer influence the timing of key events during grain development in US spring wheat. J. Cereal Sci., 37: 9-20.
26. Solomon, K.F., M.T. Labuschagen and A.T.P. Bennie, 2003. Responses of Ethiopian durum wheat genotypes to drought stress. South African J. Plant Soil, 20: 55-58.
27. Ozturk, A. and F. Aydin, 2004. Effect of water stress at various stages on some quality parameters of winter wheat. Crop Science, 190: 93-99.
28. Pierre, C.S., C.J. Peterson, A.S. Ross, J.B. Ohm, M.C. Verhoeven, M. Larson and B. Hoefer, 2008. White wheat grain quality changes with genotype, nitrogen fertilization and water stress. Agon. J., 100: 414-420.
29. Liu, L., B.C. Xu and F.M. Li, 2007. Effects of limited irrigation on yield and water use efficiency of two sequence-replaced winter wheat in Loess plateau, China. African J. Biotechnol., 6: 1493-1497.