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The Effect of Drought Stress on Grain Yield, Yield Components and Protein Content of Durum Wheat Cultivars in Ilam Province, Iran

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***Abstract*—**In order to study the effect of drought stress on grain yield, yield components and associated traits of durum wheat cultivars, an experiment was done as split plot arrangement using randomized complete block design with three replications in Ilam province, Iran in 2009-2010 cropping season. Different levels of irrigation (Full irrigation, drought stress at stem elongation, Flowering and grain formation stages) were considered as a main plot and three durum wheat cultivars (Yavaros, Seimareh and Karkheh) were assigned as a sub plot. The results showed that drought stress was significant on grain yield, spike.m^{-2}, grain. Spike^{-1}, 1000-grain weight, biological yield, harvest index and protein content. Drought stress at all stages caused a loss in grain yield and its components. Full irrigation had the highest grain yield and yield components. Drought stress at stem elongation, flowering and grain formation stages caused a reduction in spike.m^{-2}, grain.spike^{-1} and 1000-grain weight, respectively. Protein content was significantly affected by drought stress. The highest protein content was obtained from drought stress at grain formation stage. Cultivars had an influence on grain yield and yield components. Yavaros and Seimareh cultivars had the highest and lowest grain yield, respectively. Interaction effect between drought stress and cultivar had a significant effect on grain and yield components. Full irrigation and Yavaros cultivar had the highest grain yield and drought stress at grain formation stage and Seimareh cultivar had the lowest grain yield, respectively.

***Keywords*—**Durum wheat, Drought stress, Grain yield.

I. Introduction

DROUGHT stress affect plant growth via tillering, leaf photosynthesis, leaf senescence, number of grain and grain size [1]. Due to the decrease in rainfall in recent years, the temperature raised and also the drought stress increased in central and western parts of Iran, the cultivated wheat is subject to drought stress related changes in its growing season [2]. Naseri et al. [3], Mirzaei et al. [4], Ali et al. [5] stated that grain yield is mainly influenced by grain.spike^{-1}, their studies also showed that grain yield, grain.spike^{-1} and 1000-grain weight in irrigated condition were more than the conditions which are under drought stress. In a study conducted in Saudi Arabia, it was observed that spike.m^{-2}, 1000-grain weight and grains.spike^{-1} are the most important variables that effect grain yield in drought stress conditions. According to these results, it is reasonable to assume that under drought stress, an increase in three components including spikes.m^{-2}, grain.spike^{-1} and 1000-grain weight can improve grain yield [6]. Gonzalez et al. [7] indicated that under drought stress, spikes.m^{-2} acts more effectively in reducing grain yield, grain.spike^{-1} and 1000-grain weight reduce the amount of grain yield less than spikes.m^{-2}. Akram et al. [8] reported that water deficit significantly increase the sterility of spikelet and also decreased grain yield and 1000-grain weight. It is probable that the physiological mechanisms of drought-sensitive cultivar will be affected more than more resistant cultivar. According to Singh [9] drought stress affects plants phenology by shortening growth period and accelerating maturity. Kheiralla et al. [10] in an experiment on 12 cultivar of wheat under drought stress and reported that the decrease in moisture cause a significant decrease in spike.m^{-2}, grain.spike^{-1} and 1000-grain weight. Kobota et al. [11] showed that the severe drought stress compared to mild drought stress significantly reduce the size and grain weight due to the reduction in remobilization and assimilations and reduction in 1000-grain weight and grain.spike^{-1} lead to reduction in grain yield.

Gooding et al. [12] in their studies on intensity and duration of drought stress on wheat reported that drought stress reduced grain yield and 1000-grain weight by shortening the grain formation period. They also stated that its most effect is at grain formation period, 1 to 14 days after flowering had taken place. Winkel [13] found that in crops the most sensitive step to drought stress is the period between start of flowering to flowering stage, and the cultivar which is able to produce a high amount of biomass and increase the supply of assimilate in their roots are considered as more resistant cultivar. Ehdaei [14] reported that the characters such as days to flowering, days to maturity, biological yield, grain weight, grain yield and harvest index are significantly different in wheat genotypes in conditions of extreme moisture and drought stress condition. Eivazi et al. [15] reported a reduction in the value of some attributes such as gluten, glutenin; and increase in the protein of grains, gliadin, grain hardness index, falling number and the amount of water absorption by the flour under drought and salt stresses. Sial et al. [16] by investigating the effect of high temperature stress at grain formation stage on the qualitative and quantitative traits of wheat reported a 4% increase in the amount of protein under stress due to the reduction in grain weight. The results of the studies conducted by many researchers show that drought stress at different

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stages of wheat growth leads to a reduction in dry matter (biomass), grain yield, harvest index and yield components [12], [17], [18].

The aim of this study was to identify the sensitive stages of growth in wheat and also to investigate the reaction of grain yield and yield components to drought stress.

II. Materials and methods

A. Site Description

In order to investigate the effect of drought stress on grain yield and yield components of wheat, an experiment was conducted in Ilam province, Iran during in 2009-2010 cropping season. It was placed in 33 degrees latitude and 7 minutes north, and the longitude was equal to 46 degrees and 10 minutes east, and the altitude was 155 m above sea level. The study was conducted using split plot based on randomized complete block design (RCBD) with three replications. The main plot was composed of four different levels of drought stress (full irrigation, drought stress at the beginning of stem elongation, flowering and at grain formation stage) and cultivar (Karkhe, Seimereh and Yavaras) were chosen as sub plot. The related statistics and weather and the physical and chemical properties of soil are presented in Tables I & II.

B. Experimental Details

Land preparation operations consisted of using a chisel plow and disk harrow. The number of seeds of the three cultivar was set based on a 450 plants per square meter. Date of planting was 15 November, 2009. Each plot of the experiment consisted of six rows with a space equal to 25 cm and their length was 4 meters.

TABLE I
Monthly Mean Value of Precipitation and Relative Humidity in Ilam Station in 2009-2010 Cropping Season

Month	Minimum temperature mean average	Maximum temperature average	The amount of rainfall	Minimum humidity	Maximum humidity
	Min temp (°C)	Max temp (°C)	Precipitation (mm)	Min. RH (%)	Max. RH (%)
Oct.	18.1	36.9	0.4	14	46
Nov.	15.4	27.5	21.0	34	70
Dec.	8.9	19.5	24.6	48	88
Jan.	9.7	20.9	15.7	40	80
Feb.	8.6	20.2	31.7	34	78
Mar.	14.1	26.0	27.2	25	62
Apr.	15.2	29.1	34.0	20	61
May	21.5	35.0	22.7	14	47
Jun	27.1	44.0	0.0	7	23
Jul	29.5	45.7	0.0	8	23

TABLE II
Physical and Chemical Properties of Soil in the Experimental Area

Soil texture	Available P (mg kg^{-1})	Available K (mg kg^{-1})	Total N (%)	Organic Carbon (%)	E.C(dS/m)	PH
Silt loam	6.8	220	0.08	0.9	1.69	7.05

Based on tests done on the soil and plant requirements, these fertilizers were used: phosphorus, potassium and nitrogen. Based on the results of soil test, 125 $kg.ha^{-1}$ urea and 150 kg potassium sulfate was added to the soil. 180 $kg.ha^{-1}$ phosphor fertilizer was used that it was equal to 100% of recommended fertilizers. One-third of urea fertilizer and the total amount of other fertilizers were distributed in the soil before planting and in the process of substrate preparation of the soil, and they were mixed with soil. The remainder of urea fertilizer was used in tillering stage and also in stem elongation stage in the form of top dressing use. During the growing season, weeds were controlled manually. In this study, no disease or pest was reported. The space between main plots was 2 meters and the space between sub-plos was half a meter.

C. Crop Sampling and Calculation

Sampling was done from the two middle rows with eliminating the beginning and end of each side of plots. After eliminating the marginal lines on the both sides and also eliminating half a meter from the beginning and end of each line, the amount of yield was measured. $Spike.m^{-2}$ was calculated in a 1 m^2.grains.$spike^{-1}$ was calculated in 10 randomly selected spikes. 1000-grain weight was also measured by measuring the weight of 1000 grain. And also to measure protein content, a certain amount of grain was prepared from every replication and was sent to laboratory and Kijdal measurement method was used.

D. Statistical Analysis

Ultimately analysis of variance (ANOVA) was done using SAS 9.1 statistical software. Mean comparison was also conducted with Duncan's Multiple Range Test (DMRT).

III. Results and Discussion

A. $Spikes.m^{-2}$

The results indicated that there is a significant difference in the treatments under drought stress in terms of $spikes.m^{-2}$ at 5% level of probability (Table III). Full irrigation had the highest $spikes.m^{-2}$ and the drought stress at stem elongation had the lowest $spikes.m^{-2}$ (Table IV).

Drought stress at stem elongation stage is highly sensitive, because this stage is the entry of plant to the reproductive phase. Therefore it is determinant about yield components including the spikes.m^{-2}, flower number in spikes, and finally grain yield. This shows the importance of irrigation at the developmental stage in the development of double ridge at the final stages of development, the beginning of stemming.

Day and Intalap [19] also stated that drought stress at the beginning of stemming cause a reduction in the spikes.m^{-2} and 1000-grain weight. The results of this study showed that the existence of moisture during the formation of the ending development process which coincides with the end of stem elongation stage has a significant role in higher yield of wheat. The number of fertile tillers which ultimately lead to spikes.m^{-2} is determined at stem elongation stage.

At this stage, the reduction in the amount of water absorption cause a reduction in spikes.m^{-2}, drought stress during flowering and grain formation stages does not affect spikes.m^{-2} (Table IV).

Irrigation at the first stages of wheat development affects the success of plant in producing more tillers and more spikes. But after this stage the number of fertile tillers is determined, so irrigation at flowering and grain formation stages does not have any effect on spikes.m^{-2}. The results of the studies conducted by Jones et al. [20] showed that the shortage in irrigation at flowering stage largely affect the number of grain. A significant difference was observed in different cultivars under study in terms of spikes.m^{-2}. As a simple comparison of the table of data shows, the Yavarus cultivar had the highest spikes.m^{-2}and the Seimareh cultivar had the lowest spikes.m^{-2}. The results indicate a high genetic difference in the cultivar under study in terms of spikes.m^{-2}. The effect of the interaction between different cultivars and irrigation on the number of spikes.m^{-2}was significant at 5% level of probability. The maximum number of spikes.m^{-2} was achieved of the treatment with full irrigation and Yavarus cultivar. And the lowest number of spike was observed in the treatment in which there was a drought stress at flowering stage and Seimareh cultivar was used. Considering the results of grain yield in different cultivar under study, we can conclude that one of the important reasons of yield stability of genotypes under drought stress is the ability of producing high spikes.m^{-2}. Also the lowest spikes.m^{-2} in the treatment with a drought stress at flowering stage can be recognized as a reason in the reduction in grain yield compared to the full irrigation treatment and Seimareh cultivar.

B. Grains.Spike^{-1}

There was a significant difference by drought stress on grains.spike^{-1} at 5 % level of probability (Table III). Full irrigation had the highest grains.spike^{-1} (55.6 grains) and the drought stress at flowering stage had the lowest grains.spike^{-1} (37.6 grains) (Table IV). It is clear that lack of moisture at flowering stage can lead to an unsuitable inoculation, because inoculation takes place at this stage that results in abortion of florets in spikelet.

Also we can point to the decrease in the number of flowers and the sort of flowers that turn to grain as one of the reasons of grain reduction under drought stress. On the other hand we know that phloem transport of materials is dependent on photosynthesis which provides the material and also on metabolism of reservoir. According to Duncan's multiple range test, at 5% level of probability, there is not a significant difference in each column which their mean have common letters. Drought stress reduces photosynthesis and also consumption of photosynthesis material in developing leaves, therefore drought stress, indirectly, reduces the amount of materials exported from leaves. The transference of sap from phloem is dependent to the potential pressure, since in drought stress conditions, the pressure of water in phloem decreases, so this reduction leads to a reduction in the transfer of photosynthesis material and finally it decreases the amount of material storage. This fact increases the vulnerability of grain formation under drought stress. Drought stress at flowering stage reduces the amount of floret sterility and leads to a reduction in grains.spike^{-1} compared to other treatment. Drought stress after this stage and at grain formation stage has a little effect on the floret survival in spikes. The effect of drought stress at flowering stage on the sterility of florets is high and the lowest grains.spike^{-1} is observed in this conditions. There is a significant difference among different cultivars under this study in terms of grains.spike^{-1}. Fischer et al. [21] reported that the grains.spike^{-1} is reduced under drought stress. Grains.spike^{-1} is the most important component in yield changes of wheat in response to environmental condition, particularly in response to drought stress at pre-pollination stage. As a simple comparison of the table of data shows the highest grains.spike^{-1} is devoted to the Seimareh cultivar (49.5 grains) and the lowest grain number belongs to the Yavarus (39.3 grains) cultivar. Grains.spike^{-1} is one of the important components of grain yield in wheat; the genotypes that show stability to this trait mostly show a better tolerant to drought stress. But when we want to decide about the cultivar to plant, grain weight is also important [22]. The interaction between irrigation and cultivar in terms of grains.spike^{-1} is significant at 1% level of probability (Table III). The maximum and minimum grains.spike^{-1} belongs to the Seimareh cultivar and full irrigation (66.3 grains) and Yavarus cultivar and drought stress at flowering stage (40.3grains), respectively (Table V). We can say that the highest grains.spike^{-1} cannot be regarded as an advantage and does not have a significant affect in increasing grain yield. Instead it seems that the spikes.m^{-2} and 1000-grain weight has a more effective role in grain yield.

C. 1000- Grain Weight

The results of the analysis show that there is a significant difference at 5 % level of probability in terms of 1000-grain yield in relation to drought stress treatments. The full irrigation (38.1 g) and drought stress at grain formation stage (29.4 g) have the highest and lowest 1000-grain weight, respectively (Table IV).

TABLE III
ANALYSIS OF VARIANCE AND MEAN SQUARE FOR IRRIGATION TREATMENT AND CULTIVAR ON YIELD AND ITS COMPONENTS OF DURUM WHEAT IN ILAM CLIMATE

S. O. V	df	Spike.m^{-2}	Grain.spike^{-1}	1000-grain weight	Grain yield	Harvest index	Biological yield	Protein content
Replication	2	3247.2	1206.02	301.6	995743.3	4.08	68231365.2	1.9
Irrigation	3	*6928.1	*240	*122.8	**4315891.5	*49.7	8107388.3*	4.2 *
Error 1	6	1106.7	33.3	34.2	356112.1	4.5	1843288.1	1.8
Cultivar	3	**4291.2	**272.3	**120.7	**3744762.1	**40.2	**13030706.6	3.06 ns
I × V	6	*1917.1	**59.2	*19.9	**561447.1	*12.5	680168.6 ns	0.90 ns
Error 2	16	641.6	9.4	4.5	191237.5	3.9	20007031	1.1
(%)cv	-	9.6	8.1	7.9	12.8	6.1	13.5	7.2

ns, *and **: Non-significant, Significant at 5% and 1% probability levels, respectively.

Drought stress at grain formation stage leads to a reduction in grain yield. When the plant is at grain formation stage and it is in the final stages of development, all components of plant act as resource and transfer all their photosynthesis stored material into the grain. Therefore the existence of any stress at this stages causes wrinkling, the smallness and wasting of grains. The reduction in grain weight can be due to the reduction in supplying propagated material in grain. Of course, the reduction in the speed of material transferee and the decrease at grain formation period can increase the reduction of grain weight. The most important variables which are affected by lack of moisture at the end of the season and after pollination is 1000-grain weight. They also stated that drought stress during grain formation stage mainly affects 1000-grain weight and leads to its decrease [23].

In fact grain weight is a function of the speed and the duration of grain formation period. The existence of environmental stresses such as drought stress especially at grain formation period leads to a reduction in the amount of photosynthesis, the speed and duration of grain formation period and finally it leads to a reduction in grain weight. In the research conducted by Pandy et al. [24], when drought stress was applied at flowering stage, grain yield reduced due to the reduction in grain weight. Gooding et al. [12], in a study about the intensity and duration of drought stress in wheat reported that drought stress cause a reduction in 1000-grain weight and hectoliter by shortening the grain formation period. The difference in the cultivars affects 1000-grain weight ay 1 % level of probability (Table III).

Among the cultivars under study, the highest and lowest 1000-grain weight belongs to Yavarus with mean of 35 g and Seimareh with mean of 29.2 g, respectively (Table IV). Interaction effect between irrigation treatments and cultivars on 1000-grain weight was significant a1 5% level of probability (Table III).

TABLE IV
MEAN COMPARISON OF MAIN EFFECTS OF IRRIGATION TREATMENT AND CULTIVAR ON YIELD AND ITS COMPONENTS OF DURUM WHEAT

treatment	Spike.m^{-2}	Grain.spike^{-1}	1000-grain weight (g)	Grain yield (kg .ha^{-1})	Harvest index (%)	Biological yield (kg .ha^{-1})	Protein content (%)
Irrigation							
Full irrigation	377.2a	55.6a	38.1a	5550a	41.6a	13008.8a	11.3b
Drought at stem elongation stage	299.5c	45.1b	34ab	4123.3b	36.8b	11022b	12.4ab
Drought at flowering stage	34202bc	37.6c	33.4ab	4006.6b	36.7b	10983.3b	12.3ab
Drought at grain formation stage	350.7ab	43.4b	29.4b	4223.3b	37.3ab	10983b	12.9a
cultivar							
Yavarus	359.2a	39.3c	35a	4997.5a	41.9a	12370.6a	12.5a
Seimareh	323.6b	49.5a	29.2b	3713.3b	36.4b	10331.6b	12.3a
Karkheh	342.1a	44.9b	34.1a	4616.6a	39b	11550ab	12.1a

Means in each column followed by similar letter(s) are not significantly different using Duncan's Multiple Range Test.

The maximum and minimum 1000-grain weight belongs to the Yavarus cultivar and full irrigation and the Seimareh cultivar and drought stress at grain formation stage, respectively (Table V).

E. Grain Yield

The results of the analysis indicate a significant difference by drought stress treatments at 1% level of probability (Table III). In general, applying drought stress at every stages of growth caused a reduction in grain yield compared to the control treatment. The highest grain yield belonged to the control treatment with mean of 64006 kg.ha^{-1}. The lowest grain yield belonged to the treatment with drought stress at flowering stage with mean of 5550 kg.ha^{-1} (Table IV). Gooding et al. [12] in a study conducted on the intensity and duration of applied drought stress reported that drought stress causes the shortening of maturity period, reducing grain yield and reducing 1000-grain weight. Ehdaei [14] reported that some traits such as the number of days to maturity, the number of days to pollination, biological yield, grain yield, grain weight and harvest index of wheat genotypes under optimum moisture condition and drought stress at the final stages of growth are significantly different. The effect of different cultivars on grain yield was significant at 1% level of probability (Table III). Among the cultivars under study the Yavarus cultivar (4997.5 kg.ha^{-1}) and the Seimareh cultivar

(3713.3 kg.ha^{-1}) had the highest and lowest grain yield respectively (Table IV).

In this study, it was found that both the spikes.m^{-2} and 1000-grain weight was in a better condition compared to other cultivars. Although the grain. Spike^{-1} was higher in Seimareh cultivar compared to other cultivar, but spike.m^{-2} and 1000-grain weight was lower in this cultivar. Interaction effect between irrigation and cultivar on grain yield was significant at 5% level of probability. Different cultivar showed different reactions to different levels of irrigation in terms of grain yield. So that the highest yield belonged to Yavarus cultivar and full irrigation and the lowest grain yield belonged to Seimareh cultivar and drought stress at flowering stage (Table V).

D. Harvest Index

The harvest index indicates the distribution of photosynthesis materials between the economic and other reservoirs of the plant. Statistically, the effect of irrigation on harvest index was significant at 5% level of probability. Full irrigation (41.6%) had the highest harvest index and drought stress at stemming (36.8%) and flowering (36.7%) stages had the lowest harvest index. In every column, according to Duncan's multiple range tests, the means with common letters did not have a significant difference at 5% level of probability.

The reason of harvest index reduction probably is the fact that the transference of assimilates to the grain has decreased due to lack of moisture and leads to a reduction in grain yield. The results of other researchers also show that harvest index will decrease in the treatments under drought stress due to the effect of drought stress on grain yield [25]. The results of many researches show that drought stress at different stages of the growth of wheat lead to a reduction in the yield of biomass, grain yield, harvest index and grain yield components of wheat [12], [17], [18]. The harvest index was significantly different in different cultivar of wheat (Table IV). The highest harvest index was obtained of Yavarus cultivar (41.9%) and the lowest harvest index belonged to Seimareh cultivar (36.4%). It seems that the reason for this difference is the low amount of 1000-grain weight in Seimareh cultivar and also the highest spikes.m^{-2} in Yavarus cultivar. Ehdaei [14] reported that some traits including the number of days to maturity, the number of days to pollination, biological yield, grain weight, grain yield and harvest index in genotypes of wheat are significantly different under full irrigation condition and under conditions with drought stress at final stages of plant development. Interaction effect between irrigation and wheat cultivar on harvest index was significantly different at 5% level of probability (Table III). The comparison of the means showed that the highest harvest index belongs to the Yavarus cultivar and full irrigation and the lowest harvest index belongs to the Symereh cultivar and drought stress at grain filling formation (Table V).

E. Biological Yield

There was a significant difference by drought stress on biological yield at 5% level of probability (Table III). Full irrigation had the highest biological yield (13008.8 kg.ha^{-1}) and drought stress at grain formation stage had the lowest biological yield (10983 kg.ha^{-1}) (Table IV). This difference can be due to the decrease in the ability of different cultivar in absorbing nutrients, composing and transferring assimilate due to water shortage that leads to a reduction in biological yield [26]. The increase in biological yield of plants under favorable irrigation can be due to the expansion of leaf surface and also its higher durability that leads to higher biological yield by producing an efficient physiological source for absorbing more light. Based on the results of the analysis, there was a significant difference in different cultivars in terms of biological yield. The Yavarus cultivar (12370.6 kg.ha^{-1}) and the Seimareh cultivar (10331.6 kg.ha^{-1}) obtained the highest and lowest biological yield, respectively. It has been reported that usually the cultivars which have longer growing season have higher biological yield [27].

Ehdaei [14] reported that some traits including the number of days to maturity, the number of days to pollination, biological yield, grain weight, grain yield and harvest index in genotypes of wheat are significantly different under full irrigation condition.

F. Protein Content

The results of the analysis of variances showed that protein content was significant affected by drought stress (Table III). In general, full irrigation and drought stress at grain formation stage had the lowest and highest protein content, respectively (Table IV). The increase in the protein content in grain formation stage can be explained due to the increase in 1000-grain weight by the increase happened in the amount of starch in a response to the drought. The percentage of protein was not significantly different for the cultivar under study and all of them were placed in one group. Pierre et al. [28] reported that drought stress at grain formation stage leads to reduction in grain yield, 1000-grain yield, and thickness of the grain, but it also increases the means of protein content in 9 genotypes of wheat. Sial et al. [16], in a study about the effect of high temperature stress (35°C) at grain formation stage on quantitative and qualitative characteristics of wheat by indicating the reduction in 1000-grain weight, and grain yield due to the shortening of grain formation period under drought stress reported a 4% increase in protein content under drought stress condition due to the reduction in 1000-grain weight. Eivazi et al. [15] reported a reduction in the amount of some traits including gluten, glutenin, gliadin, grain hardness, falling number, the increase in protein content indexes and the amount of water absorption under drought and salt stresses.

TABLE V
MEAN COMPARISON OF INTERACTION EFFECTS BETWEEN IRRIGATION TREATMENT AND CULTIVAR ON YIELD AND ITS COMPONENTS OF DURUM WHEAT

Treatment		Spikes.m^{-2}	Grain.spike^{-1}	1000-grain weight	Grain yield (kg .ha^{-1})	Harvest index (%)	Biological yield (kg .ha^{-1})	Protein content (%)
Full irrigation	Yavarus	433.3a	45.3cd	43.3a	6133.3a	45a	14766.6a	12.2a
	Seimareh	335cd	66.3a	32.3def	4800bc	39.6b	11793.3bc	12a
	Karkhe	363bc	51.6b	39.3ab	5216.6b	40.3b	12466.6ab	10b
Drought at stem elongation stage	Yavarus	315cd	43.3cd	37bc	4633.3cd	38bc	11732.6bc	12.7a
	Seimareh	290d	49.3bc	31defg	3586.6ef	35c	9866.6bc	12.4a
	Karkhe	32303cd	46.3cd	34cde	4450cd	37.3bc	11466.6bc	12.2a
Drought at flowering stage	Yavarus	350bc	40.3d	35.3bcd	4503.3cd	37.6bc	11600bc	12.5a
	Seimareh	333.3bcd	45.3cd	30efg	3816.6def	35.3c	10133.3bc	12.2a
	Karkhe	343.3bc	52.3d	34cd	4400cde	37.3bc	11216.6bc	12.1a
Drought at grain formation stage	Yavarus	338.6bcd	44.3cd	29.3fg	4220de	36c	11383.3bc	13a
	Seimareh	332bcd	49.3bc	28.6g	3450f	34c	9533.3c	12.8a
	Karkhe	316.6b	46.3cd	31.6cdef	4700c	41.6b	11050bc	12.6a

Means in each column followed by similar letter(s) are not significantly different using Duncan's Multiple Range Test.

In conclusion, the results of this study shows the reaction of yield and yield components to drought stress and also it shows the significant difference of wheat cultivars in terms of grain yield. All of the growth stages are extremely sensitive in reaction to water, and drought stress can affect yield and yield components to an extreme degree. Drought stress at stem elongation stage will decrease spike.m^{-2} [3], [4].

At flowering stage, it causes the infertility of florets and consequently a decrease in grain.spike^{-1}. Drought stress at grain formation stage also caused a reduction in 1000-grain weight.

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