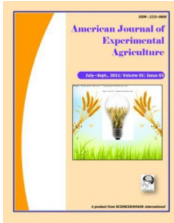

American Journal of Experimental Agriculture
4(12): 1944-1957, 2014
ISSN: 2231-0606

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Effect of Preceding Crops and Supplementary Irrigation on Yield and Yield Components of Two Varieties of Common Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Author ASK designed the study, wrote the protocol and wrote the first draft of the manuscript. Author DSAM managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2014/10889
Editor(s):
(1) Özge Çelik, Department of Molecular Biology and Genetics, Istanbul Kultur University, Turkey.
Reviewers:
(1) Awale Degewione Shirdon, Horticulture, Jimma Univ. of College of Agri. and Veterinary Medicine, Ethiopia.
(2) Agnieszka Ostrowska, The Franciszek Górski Inst. of Plant Physiology of the Polish Academy of Scie., Poland.
(3) Daniel de la Torre Llorente, Plant Biology Dept., ETSI Agrónomos, Universidad Politécnica de Madrid, España.
(4) Anonymous, National University of Litoral, Argentina.
Peer review History: http://www.sciencedomain.org/review-history.php?iid=586&id=2&aid=5829

Original Research Article

Received 15th April 2014
Accepted 25th June 2014
Published 21st August 2014

ABSTRACT

The experiment was carried out at the farm of the Faculty of Agriculture and Forestry, University of Duhok, Kurdistan Region, at Sumail county, for the growing season 2010-2011. A Randomized Complete Block Design (RCBD) in spilt-spilt plot arrangement, with three replications was designed including the preceding crops (Fallow, Barley, Sunflower and Cucumber) as the main plot, while the two supplement irrigations were allocated as a

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sub-plot, and the two wheat varieties (Abu Ghraib 3 and Sham 6) as sub-sub-plot. The results revealed that fallow land, sunflower and cucumber enhanced some traits and the highest values were recorded after cucumber for biological weight, grain weight per square meter and grain yield; which were (596.58 g, 270.64 g and 2.71 ton/ha), respectively. The increment in wheat grain yield after fallow, sunflower and cucumber in comparison with barley was 413.95%, 437.20% and 530.23%, respectively. The influence of supplementary irrigation was obvious, with the exception of harvest index and 1000-grain weight; all other traits were increased gradually by irrigation repetition. The increment in grain yield due to one and two irrigations was 37.5 and 84.55%, respectively, as compared to non-irrigation. Abu Ghraib 3 surpassed Sham 6 in the trait of number of grain/spike, it was 18.35 and 15.91, respectively. The weight of grain/spike was 0.55 and 0.50g, respectively. The least biological yield was noticed for barley with no irrigation (57.53), while application of two irrigations after fallow, sunflower and cucumber exceeded barley with an amount of 1104.59%, 1007.37%, and 1311.83%, respectively. The ultimate goal for growing wheat is grain yield; therefore it was raised after fallow, sunflower and cucumber in comparison to barley with no irrigation by 1195.45%, 1268.18%, 1536.36%, respectively. The results revealed significant interaction on some traits; they had no significant effect on grain yield and yield components between the three factors while the second order interaction was not significant.

Keywords: Supplementary irrigation; preceding crops; sham 6; abu ghraib 3; fallow.

1. INTRODUCTION

Wheat is the most important economic crop in the world; it is used mainly for human consumption (65%), animal feed (21%), and industries (14%), [1]. Therefore, it is necessary to increase wheat production to compensate the increase food supply to keep pace with growing world population. Drought is one of the most important abiotic stress that globally limit crop production on more than 26% of the world's arable land, and create huge variations in grain yield in the cultivated areas [2].

Although water availability is a major limiting factor in wheat production, the cultivars shows variable response to their resistance to drought conditions. Therefore, enhancing wheat productivity can be achieved by supplementary irrigation during the critical stage of wheat growth. The most area of wheat production in Iraqi Kurdistan region located, under rainfed conditions, usually of low yield and the annual production is fluctuating as the water availability is the major constraint limiting agricultural development [3].

The irregular precipitation and distribution lead to fluctuation in wheat production and productivity. The total area cultivated with wheat in Kurdistan region for the growing season 2011 was 650309.5 ha. The yield was 498751 tons, then productivity was 0.767ton/ha [4]. Fourteen years average yield of wheat in Iraq was (0.727 ton/ha), while the average yield of wheat for the three Kurdistan governorates (Erbil, Sulaimani and Duhok) was 0.839ton/ha [5]. On the other hand, the farming system has also its influence on wheat production. Summer fallow is commonly used to stabilize wheat production, but summer fallow results in soil degradation, limits farm productivity and profitability, and stores soil water inefficiently. The mean precipitation storage efficiency was 29%. Therefore, fallowing is not a useful tool for increasing water availability [6].

Changes in the sequence of crops grown on agricultural land are well known to enhance the yield of grain crops such as wheat. A survey of the literature gathered from around the world shows mean yield benefits of up to 20% or more. The review summarizes current understanding of the 'better-known' mechanisms of crop rotation, and discusses other mechanisms (e.g. changes in rhizosphere biology, allelopathy or soil structure) that may help to account fully for the rotation benefits that have been observed by agricultural producers for more than 2000 years [7].

In respect to wheat cultivars, a significant genetic variation was observed for the agronomic and physiological traits investigated by [8] in their study under rainfed and irrigated condition including parents and their hybrids. According to the preview, the present research work was designed to investigate the influence of the preceding farming system, supplementary irrigation on yield and its components of two bread wheat cultivars.

2. MATERIALS AND METHODS

The experiment was carried out at the farm of the Faculty of Agriculture and Forestry, University of Duhok, Kurdistan Region, at Sumail county, which is located 15km west Duhok City, at latitude 36º.84" N, and longitude 40º.01" E and elevation of approximately 583 masl, during the winter season 2010-2011. The experiment was established in a soil classified as vertisol, silty clay in texture of semi arid climatic condition, with pH (7.8) organic matter (1.48%) [9], with different preceding crops which were considered one of the experiment factor.

The preceding crops comprised fallow when the field was ploughed twice with mould board plow, the first operation was in October 2009, and the second plowing was in April 2010. The barley field was grown with barely during the season of 2009, with fertilization application at a rate of 40kg/ha NPK hand broadcasted and harvested in early June 2010. While for sunflower the field was ploughed twice during winter season of 2009-2010, and sunflower seeds were sown on April 26th, 2010 Field irrigation was based on plants requirement, weeds were controlled manually by hand. On 17th of June the field was fertilized with nitrogen and phosphor (18% N and 23% P); fertilizers were applied at a rate of 320 kg/ha, banded little above the bottom of the rows [10].

Finally during winter months of 2010 another part of the field was ploughed twice with mould board plow and planted with cucumber (*Cucumis sativa* L.). On April 17th, 2010, the fertilization process was conducted by addition of 280kg/ha of Urea, with 129kg/ha of phosphate during the season as two intervals the first after four weeks from planting, and the second after one month of the first [11].

The land of the above preceding crops was prepared for growing wheat; it was ploughed twice, first in October 20th, 2010 with mouldboard plow, and for the second time it was ploughed in December 19th, 2010 with one way disc plow perpendicular to the first one. Two varieties of wheat, Abu Ghraib 3, from Ninevah Agricultural Research Station, and Sham 6 from Duhok Agricultural Research Station, the purity was 98% and 97% and the germination was 99% and 98% for Sham 6 and Abu Ghraib 3, respectively. And the 1000-grain weight was 27.22 g and 22.37g for Sham 6 and Abu Ghraib 3, respectively. The seeding rate was adjusted on the basis of 120Kg/ha for Abu Graib 3, to achieve 500.67 grain/row of four meter length, this was corresponded to 146Kg/ha for Sham 6 to achieve 500.67 grain/rows, and sowing on December 19th, 2010.

Abu Ghraib 3, recommended growing under irrigation and dry farming condition of assured and semi assured annual rainfall. Lodging and rust resistance, respond to NP fertilization, suitable for bread, it is of moderate maturity and of high productivity. Abu Ghraib 3 is cross of [Ajeba (introduced from India) × Inia 66 (introduced from Mexico) × Mexico 24]. Sham 6, was introduced from ICARDA, Aleppo, Syria is a spring variety, suitable for irrigated area, and lodging and disease resistance [12].

Random soil samples were collected depending on preceding crops, at two depths of (0-20 and 20-40 cm, it was prepared for some physical and chemical characteristics , as shown in Table 1 which were measured at the laboratory of Soil and Water Science Department. The soil characteristics were determined according to [13]. Soil extract of 1:1 was used for measuring soil pH using pH meter and potassium by flame photometer instrument. Total nitrogen was measured by Micro-Kjeldhal instrument [14].

Table 1. Physical and chemical properties of the soil of the experiment site

Soil characters							**Average value**	
Particle size distribution	Sand g/Kg						84	
	Silt g/Kg						414.0	
	Clay g/Kg						501.0	
	Bulk density Mg/m^3						1.43	
	Moisture content at field capacity (-33kpa)						29.4%	
	Moisture content at wilting point (-1500kpa)						18.25%	
	Electrical conductivity ds m^{-1}						0.397	
	Fallow		Barley		Sunflower		Cucumber	
	Soil depth (cm)		**Soil depth (cm)**		**Soil depth (cm)**		**Soil depth (cm)**	
	0-20	**20-40**	**0-20**	**20-40**	**0-20**	**20-40**	**0-20**	**20-40**
Soil pH	7.96	7.97	8	8.01	7.86	7.88	7.81	7.95
Organic matter (g/kg)	14.1	14.3	15.1	10.1	13.8	10.2	11.7	14.8
Available Nitrogen (mg/kg)	110	120	50	50	70	50	300	100
Available phosphorous (mg/kg)	5.87	5.49	5.00	4.59	10.85	8.48	6.70	5.39
Soluble Potassium (mmol L^{-1})	0.65	0.61	0.67	1.29	1.39	0.94	0.74	0.60

Organic matter was measured by wet digestion method using concentrated sulphuric acid Walky and Black method according to [15].

The climatically information represented in Table 2.

To supplement rainfall with irrigation, two irrigations were applied, the first one on April 16th, 2011, at wheat booting stage, plant depending on soil moisture depletion to approach the field capacity which was (29.4%).

While the second irrigation was applied on May 5th, 2011 at anthesis stage. The amount of water required was determined according to [16].

$$d = \frac{Mfci - Mbi}{100} * Ai\ Di$$

d = net irrigation water to be applied (cm).

Mfci = moisture contain percentage at field capacity in 30cm layer (29.4%) [17].
Mbi = moisture contain percentage before irrigation in 30cm layer.
Ai = Bulk density (1.43 Mg/m^3) at 30cm layer.
Di = depth (cm) of the soil layer.

$$Q = A * d$$

Q = amount of water need to irrigate until field capacity (m^3).
A = plot area (5.6 m^2).
d = depth of supplement irrigation (m)

The water was added using water gauge connected with plastic hoes ended with a circular bath shower of 20cm diameter, for uniform distribution and to resemble rain.

The amount of added water was represented in Table 3.

The experiment was designed as Randomized Complete Block Design (RCBD) in spilt-spilt plot arrangement, with three replications. The land divided into three blocks, (each of 24 plots), the experiment unit was 1.4×4 m (5.6 m^2). The main plot was assigned for the preceding crops, the two supplement irrigations were allocated as a sub-plot, while the two wheat varieties allocated as sub-sub-plot. The blocks were 2m apart from each other, while the distance between plots was 1.5 m apart, between each sub-plots 0.5m, which consists of six rows of 4m length, and 0.2m between lines. Wheat yield and yield components comprised, spike length (cm) excluding awn, number of grain/spike, weight of grain (g)/spike, above ground biomass g/m^2, $(\mathrm{Biological\ yield} = \mathrm{straw} + \mathrm{grain})$, weight of grain/$m^2$, harvest index $= \frac{\mathrm{grian\ yield}}{\mathrm{biomass\ above\ ground}} \times 100$, according to, Sharma and Smith [18], 1000-grain weight (g), grain yield ton/ha.

Table 2. Monthly average temperature, atmospheric relative humidity and rainfall during the study season (2010-2011)

Season 2010-2011	Monthly average temperature ºC	Monthly average atmospheric relative humidity (%)	Monthly average rainfall (mm)
October	30.3	32.6	0.5
November	14.8	28.3	-
December	6.61	45.9	62.4
January	7.95	59.1	80.5
February	8.45	57.5	55
March	10.24	42.7	19.6
April	15.05	49.73	138.3
May	21.8	43	54.4
June	28.19	24.58	0.5
Total rainfall			411.2
Rainfall+ one irrigation		411.2 + 46.7	457.9
Rainfall+ two irrigation		411.2+ 77.6	488.8

** Metrological Station (2011) of the Faculty of Agriculture and Forestry, University of Duhok*

Table 3. Amount of water added as supplementary irrigation

	1st irrigation			2nd irrigation		
	Moisture content (%)	**Added water (liter)/plot**	**Correspond to rain fall (mm)**	**Moisture content (%)**	**Added water (liter)/plot**	**Correspond to rain fall (mm)**
Fallow	18.00	273	48.75	22.11	175	31.25
Barley	18.56	260	46.42	21.88	180	32.14
Sunflower	19.33	241.9	43.19	22.73	160	28.57
Cucumber	18.01	273.6	48.85	22.01	177.5	31.69

The collected data were subject to analysis of variance using SAS program (Version 9.0, 2001). Means of each factor levels and their interactions were verified according to [19] at 5% level, whenever significant.

3. RESULTS AND DISCUSSION

The results shown in Table 4 revealed that barley in general has the most deleterious effect on all studied traits, including (spike length, number of grain/spike, weight of grain/spike, biological yield, straw weight, weight of grain/m^2, harvest index, 1000-grain weight and grain yield/ha). Sunflower resembles cucumber in its effect on spike length, number of grain/spike, weight of grain/spike, straw weight/m^2, harvest index and 1000 grain weight. While cucumber gave higher value than all other systems, in biological weight, grain weight/m^2 and grain yield; which were (596.58 g, 270.64 g and 2.71 ton/ha), respectively. The increment in wheat grain yield succeeded fallow, sunflower and cucumber in comparison with barley was 413.95%, 437.20% and 530.23%, respectively. The enhancement after fallow, sunflower and cucumber was attributed to the benefit from the fertilization of these crops which improved soil fertility as it is shown in soil analysis in Table 1.

Similar results have been noticed by [20] who stated that when the preceding crops were cereals including barley, they resulted in a significant reduction in wheat yield. Moreover, the passiveness effect of barley was attributed to its allelopathic effect on durum wheat according to [21] who found that barley residues reduced wheat plant height, root length and the dry weight.

The moisture that conserved after fallowing or during growing these summer crops (sunflower and cucumber) might have some beneficial effects on subsequent grown wheat. This was confirmed by [22] who found that sunflower has a positive effect on the subsequent grown wheat. However, [23] reported that sunflower and soybean caused reductions in subsequent wheat yield and this was also confirmed by [24] who noticed that wheat yield was higher after fallow rotation than after sunflower. The influence of supplementary irrigation was significant, with the exception of harvest index and 1000 grain weight; all other traits including grain yield and its components were increased progressively by irrigation frequency.

Table 5 shows an enhancement in the spike length due to one and two irrigation was 11.34% and 18.46%; while it was 13.33% and 15.96% for number of grain/spike; 12.5% and 16.66% for grain weight/spike; 34.06% and 83.34% for biological yield/m^2; 31.17% and 82.06% for weight of straw/m^2; 37.78% and 84.98% for grain weight/m^2; 37.5% and 84.55% for grain yield, respectively.

The results indicated clearly that irrigation has a substantial role in grain weight accumulation more than the other characters; it was almost doubled with two irrigations compared to single irrigation. Such beneficial effect of supplement irrigation on wheat was in harmony with the results of numerous researchers [25,26,3] who illustrated that wheat productivity greatly increased by supplementing small amount as much (68 mm) of irrigation, and others [27,28,29]. The interpretation of beneficial effect of supplement irrigation is a way to compensate the soil water loss due transpiration and to release the water stress on plants in case of insufficient rainfall [30].

While [31] attributed the reduction in grain dry mass of wheat due to water stress to decrease in the grain filling period, which imposed at the watery ripe stage reduced not only the linear growth phase but also its slope, ultimately it reduced grain number/spike, 1000-grain weight. The water deficient influence on physiological activity of plant through various aspects, water deficient significantly affected gas exchange and it reduced the net photosynthesis rate, transpiration rate and stomata conductance at anthesis and grain filling stages [32]. Wheat varieties were differed significantly in term of grain yield and yield components. The results displayed in Table 6 show no significant difference between the two cultivars for the traits; spike length, straw weight/m^2; grain weight/m^2, harvest index and grain yield; Abu Ghraib 3 surpassed Sham 6 in the trait of number of grain/spike, it was 18.35 and 15.91; while the weight of grain/spike was 0.55 and 0.50 g, respectively. The reverse was true for the biological weight and 1000-grain weight, it was higher in Sham 6, it was 448.07 and 415.94; 30.75 and 29.38 for both traits and both cultivars, respectively.

The differences between wheat cultivars might be due to their genetic potential [33] noticed that Abu Ghraib 3 cultivar did not perform well under rainfed or under limited supplementary irrigation. Similarly, [34] referred to significant differences between seven wheat cultivars including Abu Ghraib 3 in most traits.

However, [35] demonstrated that Abu Ghraib 3 performed better than other wheat cultivars as it displayed least reduction in growth characters under water deficit in comparison to those grown under field capacity. Such differences between wheat cultivars has been reported by other researchers, [36,37]

Table 7 show that no significant influenced of preceding crops and supplementary irrigation with the exception of biological yield, straw and grain yield/m^2. With the exception of biological yield, straw and grain yield/m^2 and grain yield ton/ha.; all other traits were not influenced significantly by this interaction.

The least biological yield was noticed for barley with no irrigation (57.53), while application of two irrigations after fallow, sunflower and cucumber exceeded barley with an amount of 1104.59%, 1007.37%, and 1311.83%, respectively. Similarly the least value for straw and grain yield/m^2 was recorded for barley with no irrigation, but the highest was for cucumber with two irrigations. The ultimate goal for growing wheat is grain yield; therefore it was raised after fallow, sunflower and cucumber in comparison to barley with no irrigation by 1195.45%, 1268.18%, and 1536.36%, respectively.

Table 4. Effect of the preceding crops on wheat yield and yield components

Preceding crops	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
Fallow	6.48a	17.76a	0.52b	541.32ab	320.48a	220.84b	41	29.48b	2.21b
Barley	3.54b	10.00b	0.27c	100.99c	58.48 b	42.51c	40	25.99c	0.43c
Sunflower	6.50a	20.40a	0.66a	489.14b	257.83a	231.31b	47	32.46a	2.31b
Cucumber	6.36a	20.35a	0.66a	596.58a	325.93a	270.64a	46	32.33a	2.71a

Within each character's means followed by the same alphabetical letters do not differ significantly at (α 0.05) according to DMRT (1955)

Table 5. Effect of supplementary irrigation on wheat grain yield and yield components

Irrigation	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
0-I	5.20c	15.60b	0.48b	310.49c	174.73c	135.77c	42	29.69	1.36c
1-I	5.79b	17.68a	0.54a	416.27b	229.20b	187.07b	45	30.22	1.87b
2-I	6.16a	18.09a	0.56a	569.27a	318.12a	251.15a	44	30.29	2.51a

Within each character's means followed by the same alphabetical letters do not differ significantly at (α 0.05) according to DMRT (1955). 0-I- denotes to no irrigation (rainfall only), 1-I denotes to one irrigation and 2-I denotes to two irrigation. In addition to rainfall

Table 6. Effect of varieties on wheat grain yield and yield components

Varieties	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
Sham 6	5.68	15.91 b	0.50b	448.07a	251.5	196.52	43	30.75 a	1.97
Abu Ghraib 3	5.76	18.35 a	0.55a	415.94b	229.8	186.14	44	29.38 b	1.86

Within each character's means followed by the same alphabetical letters do not differ significantly at (α 0.05) according to DMRT (1955)

Table 7. Effect of the preceding crops and supplementary irrigation interaction on wheat grain yield and yield components

Preceding crops	Irrigation	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
Fallow	0-I	6.13	17.23	0.50	413.40ef	243.28ed	170.12d	41	29.39	1.70d
	1-I	6.48	17.97	0.52	517.90ed	310.39cd	207.51cd	40	29.28	2.08cd
	2-I	6.82	18.08	0.54	692.67b	407.77ab	284.89b	41	29.78	2.85b
Barley	0-I	3.23	6.53	0.17	57.53g	35.52f	22.01e	36	25.48	0.22e
	1-I	3.66	12.05	0.32	110.33g	62.86f	47.47e	42	26.06	0.47e
	2-I	3.74	11.41	0.31	135.10g	77.05f	58.05e	43	26.42	0.58e
Sunflower	0-I	5.85	20.00	0.63	352.57f	179.64e	172.93d	49	31.54	1.73d
	1-I	6.53	20.33	0.66	477.80ed	258.03cde	219.77c	46	32.72	2.20c
	2-I	7.13	20.85	0.69	637.07bc	335.82bc	301.25b	47	33.13	3.01b
	0-I	5.62	18.64	0.60	418.47ef	240.46de	178.01d	42	32.37	1.78d
Cucumber	1-I	6.49	20.38	0.67	559.03cd	285.50cd	273.53b	52	32.81	2.74b
	2-I	6.96	22.04	0.70	812.23a	451.84a	360.39a	45	31.83	3.60a

Within each character's means followed by the same alphabetical letters do not differ significantly at (α 0.05) according to DMRT (1955)

Table 8. Effect of preceding crop and varieties interaction on wheat grain yield and yield components

Preceding crops	Varieties	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
Fallow	Sham 6	6.29a	16.57	0.50	545.24	320.75	224.50	41	29.96	2.24
	Abu Ghraib 3	6.66a	18.94	0.55	537.40	320.22	217.18	40	29.00	2.17
Barley	Sham 6	3.74b	9.14	0.25	94.96	55.39	39.57	41	26.82	0.40
	Abu Ghraib 3	3.34b	10.86	0.28	107.02	61.56	45.46	40	25.15	0.45
Sunflower	Sham 6	6.33a	20.10	0.67	528.64	275.90	252.75	48	33.18	2.53
	Abu Ghraib 3	6.68a	20.69	0.66	449.64	239.76	209.88	47	31.75	2.10
Cucumber	Sham 6	6.37a	17.81	0.59	623.44	354.19	269.26	43	33.06	2.69
	Abu Ghraib 3	6.34a	22.90	0.72	569.71	297.68	272.03	49	31.61	2.72

Means followed by the same alphabetical letters do not differ significantly at (α 0.05) according DMRT (1955)

Table 9. Effect of supplementary irrigation and varieties on wheat grain yield and yield components

Irrigation	Varieties	Spike length (cm)	Number of grain/spike	Weight of grain/spike (g)	Biological weight g/m^2	Straw weight g/m^2	Weight of grain/m^2	Harvest index (%)	1000-grain weight (g)	Grain yield ton/ha
0-I	Sham6	5.01	14.17	0.44	312.88	178.12	134.76	42	30.87	1.35
	Abu Ghraib3	5.40	17.03	0.51	308.10	171.33	136.77	42	28.52	1.37
1-I	Sham6	5.80	16.62	0.53	449.87	251.32	198.54	44	31.16	1.99
	Abu Ghraib3	5.78	18.75	0.56	382.67	207.07	175.60	46	29.28	1.76
2-I	Sham6	6.23	16.93	0.53	581.47	325.22	256.25	43	30.23	2.56
	Abu Ghraib3	6.09	19.26	0.59	557.07	311.02	246.05	44	30.34	2.46

Numerous reviews have focused on the effect of the interaction of preceding crops with tillage system on subsequent wheat growth and yield, but not much was available on preceding crops with supplementary irrigation. However, the interpretation for the effect of preceding crops with supplement irrigation could be due to the beneficial from the residual soil moisture and nutrients from the previous crops to be utilized in the growth of the subsequent crops and this beneficial effect was maximized by supplementary irrigation.

The effect of preceding crops with irrigation has also been cited by other researchers [6] denoted to higher soil water for rotation with sunflower and fallow. However, [38] found that pre-plant soil water, water use and spring wheat yield were generally greater following summer fallow than wheat recropped after wheat. He added that chickpea, lentil, yellow mustard, safflower and sunflower did not perform well during periods of below average precipitation.

The preceding crops by wheat varieties interaction showed no significant effect on all traits excluding spike length which was declined after barley for both wheat varieties (Table 8) above, with the exception of spike length. However, no significant interaction between supplementary irrigation and wheat varieties effect was noticed for all measured traits (Table 9) above. Researchers [39] realized that in comparison of three wheat cultivars that water deficit reduced all plant parameters significantly including number of tillers, 100-grain weight and grain yield [40]. These results, however contradicted some other researchers, who illustrated significant differences between wheat cultivars in relation to supplementary irrigation [33] found that wheat cultivars varied in their response to supplementary irrigation, they noticed that Abu Ghraib 3 cultivar did not perform well under rainfed or under limited supplementary irrigation. Their results coincided with the results of [41] who referred to significant differences between Iraqi wheat cultivars in response to drought. However, [42] noticed significant interaction between nine wheat cultivars including Abu Ghraib 3 and Sham 6, with supplement irrigation, for almost all measured characteristics, and the Sham 6 was superior in grain yield. Researcher [35] also demonstrated that Abu Ghraib 3 performed better than other cultivars as it displayed the least reduction in growth characters under water deficit in comparison to those grown under field capacity. The investigator [43] referred to significant interaction of irrigation regimes by genotype for number of spikes/m2, number of grain/spike, plant height, and 1000-grain weight. While [44], also found differences between wheat genotypes in response to water deficit, and the genotype Toops produced the highest grain yield with both normal irrigation and with terminal drought.

Similarly the second order interaction (preceding crops x varieties x irrigation) was not significant for all measured traits.

4. CONCLUSION

The results of growing wheat after Fallow, Barley, Sunflower and Cucumber revealed that fallow land, sunflower and cucumber enhanced some traits of wheat, and the highest values were recorded after cucumber for biological weight, grain weight per square meter and grain yield. The increment in wheat grain yield after fallow, sunflower and cucumber in comparison with barley was 413.95%, 437.20% and 530.23%, respectively. The influence of supplementary irrigation was also obvious. The ultimate goal for growing wheat is grain yield; therefore it was raised after fallow, sunflower and cucumber in comparison to barley.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adary A, Hachum A, Oweis T, Pala M. Wheat productivity under supplemental irrigation in North Iraq. International center for agricultural research in the dry areas (ICARDA). Research Report Series, No.2; 2002.
2. Adary AH, Al-Rasheedy S. Studies to increase wheat productivity Northern Iraq thought supplementary irrigation. page 87-95 in workshop on technology transfer in the production of cereal and legumes. 1993;20-22. Sept, 1993. IPA Agricultural Research Center, Baghdad, Iraq.
3. Alam MZ, Rahman MS, Haque ME, Hossain MS, Azad MAK, Khan MRH. Response of irrigation frequencies and different doses of N fertilization the growth and yield of wheat. Pak. J. Biol. Sci. 2003;6(8):732-734.
4. Al-Duleimy BA, Aboud NH, Numan AH. Studies of some morphological characteristics of eight bread wheat (*Triticum aestivum L*). Cultivars. Journal of Tikrit for Agricultural Science. 2003;3(7):100-110.
5. Ali SA. Evaluation of five genotypes of sunflower (*Helianthus annuus L.)* under different plant densities. M.Sc. Thesis, College of Agricultural. Duhok University; 2012.
6. Al-Nori MAA. Effect of nitrogen fertilization and supplementary irrigation on growth, yield and quality characteristics of some local bread (*Triticum aestvium L*.). Ph.D. Thesis. College of Agricultural and Forestry. University of Mosul. Iraq; 2005.
7. Artoshy AMS. Evaluation of potential Evapotranspiration by different methods in semiarid region (Duhok governorate). M.Sc. Thesis. College of Agricultural. University of Duhok; 2010.
8. Beltrano J, Ronco GM, Arango CM. Soil drying and rewatering applied at three grain developmental stages affect differentially growth and grain protein deposition in wheat (*Triticum aestivum L*.). Braz. J. Plant Physiol. 2006;18(2):341-350
9. Black CR, Evans DD, Ensminger LE, White JL, Clark FE. Methods of Soil analysis, Part 1 and 2 Agron. Mono. Am. Soc. Agron. Madison, Wisconsin; 1965.
10. Bogale A, Tesfaye K, Geleto T. Morphological and physiological attributes associated to drought tolerance of Ethiopian durum wheat genotypes under water deficit condition Journal of Biodiversity and Environmental Sciences. 2011;1(2):22-36.
11. Bremner JM. Nitrogen availability index. In Black C A. et al. (eds). Methods of soil analysis. Am. Soc. Agron. Inc. Agron. Mono. 9. Medison, Wisconsin, USA, 1965;1324-1325.
12. Chandrasekaran B, Annaduria K, Somasundaram E. A text book agronomy. New Age International. Ltd, publisher, New Delhi; 2010.
13. Cseuz L. Possibilities and limits of breeding wheat (*Triticum aestivum L.*) for drought tolerance. PhD Thesis. Facultynce of Agricultural and Environmental Science. Szent Istvan University; 2009.
14. Dawod KM, Ali AH, Ibrahim KS. Homeostasis and genotypic resultant for cultivars of bread wheat and path coefficient analysis among yield and some of its components. J. of Iraqi Agricultural Sciences. 2004;5(1):76-82. (In Arabic).
15. Duncan DB. Multiple ranges and multiple F. Tests Biometrics, 1955;11(1):1-42.
16. FAO. Towards Sustainable Agricultural Development in Iraq. Crop production and protection. FAOSTAT. Database-Bulletin; 2001. Available: http://www.fao.org/docrep/006/Y9870E/y9870e07.htm.

17. Farshadfar E, Rasoli V J. A.Teixeira da Silva Jaime and M. Farshadfar. Inheritance of drought tolerance indicators in bread wheat (*Triticum aestivum L.*) using a diallel technique. AJCS. 2011;5(7):870-878.
18. Ghamarnia H, Gowing JW. Effect of water stress on three wheat cultivars. ICID 21st European Regional Conference, 15-19 May, Frankfurt (Oder) and Slubica, Germany and Poland; 2005.
19. Gooding MJ, Davies WP. Wheat production and utilization: Systems, quality and the environment. CAB International: Wallingford, UK; 1997.
20. Ismail S M. Optimal irrigation and wheat yield response to applied water. J. King Saud Univ. Agri. Sci. 1993;5(1):41-56.
21. Khalaf AA. Approaches the sealing performance of local materials for seepage reduction. Ph. D. Dissertation. College of Agriculture. University of Salahaddin; 2010.
22. Khalaf AS. Wheat grain tyrosinase activity as an index of drought resistance. The Indian Journal of Crop Science. 2009;4(2-1).
23. Kirkegaard J, Christen O, Krupinsky J, Layzell D. Break crop benefits in temperate wheat production. Field Crops Research 2008;107:185–195.
24. Kotal BD, Das A, Choudhury BK. Genetic variability and association of characters in wheat (*Triticum aestivum L.*). Asian J. Crop Sci. 2010;2(3):155-160.
25. Lenssen AW, Johnson GD, Carlson GR. Cropping sequence and tillage system influences annual crop production and water use in semiarid Montana, USA. Field Crop Research. 2007;100:32-43.
26. López-Bellido RJ, López-Bellido L, Benitez-Vega J, López-Bellido F J. Tillage system preceding crop, and nitrogen fertilizer in wheat crop: I. Soil water content. Agronomy Journal. American Society of Agronomy. 2007;(99):59-65.
27. Lyon JD, Baltensperger DD, Blumenthal J M, Burgener PA, Harveson RM. Eliminating summer fallow reduces winter wheat yields, but not necessary system profitability. Crop Sci. 2004;(44):855-860.
28. Ministry of Agriculture, Kurdistan Regional Government. Statistical Report, Erbil. 2011.
29. Moayedi AA, Boyce AN, Barakbah SS. The Performance of durum and bread wheat genotype associated yield and yield component under different water deficit condition. Aust. J. Basic and Appl. Sci. 2010;4(1):106-113.
30. Mollasadeghi V, Valizadeh M, Shahryari R, Imani A A. Evaluation of end drought tolerance of 12 wheat genotype by stress indices. World Appl. Sci. J. 2011;13(3):545-551.
31. Nand B, Khokhar RPS, Pyare R. Studies on irrigations scheduling of wheat varieties for centraluttar Pradesh, India. Plant Archives. 2011;11(1):243-248.
32. National Committee for Agricultural Varieties Registration and Release (NCRVRR). Ministry of Agriculture-Issue No.3- Iraqi; 2004.
33. Norwood CA. Dryland winter wheat as affected by previous crops. Agronomy J. 2000;(92):121-127.
34. Olofsson S. Influence of preceding crop and crop residue on stand and yield of winter wheat (*Triticum aestivum L.*), in different tillage systems, including zero tillage. Ph.D. Thesis .SLU, Department of Crop Teach. Crop Production Science Journal; 1993. ISSN: 1100-1186.
35. Page AL, Miller RH, Keeney DR. Methods of Soil Analysis. 2nd ed., American Society of Agronomy, Madison, WI., USA; 1982.
36. Patel CL, Patel MV. Mottling phenomena and quality of grains of different genotypes of durum wheat grown under limited irrigation conditions. Plant and Soil. 1985;87:315-318.

37. Pireivatlou AS, Yazdansepas A. Evaluation of wheat (*Triticum aestivum L.*) Genotypes under per-and post-anthesis Drought stress conditions. J. Agric. sci. Techol. 2008;(10):190-121.
38. Said A, Ahmad J, Hussaine T. Performance of different wheat genotypes under environment condition of Peshawar Valley. Sarhad. J. Agric. 2007;23(3):546-548.
39. Saied J A. The response of some durum wheat cultivars to the allelopathic effect of barley (*Hordeum distichum L.*). J. of Iraqi Agricultural Sciences. 2004;5(3):94-101.(In Arabic)
40. Schlegel A, Thompson C, Dumler T. Effect of previous crop on wheat yield. Southwest Research-Extension Center Report of Progress 997. no. 2008;08-288-S.
41. Shao L, Zhang X, Chen S, Sun H, Wang Z. Effects of irrigation frequency under limited irrigation on root water uptake, yield and water use efficiency of winter wheat. Irrig. and Drain. 2009;(58):393-405.
42. Sharam RC, Smith E L. Selection for high and low harvest index in three winter populations. Crop, Sci. 1986;(26):1147-1150.
43. Tavakkoli AR, Oweis TY. The role of supplemental irrigation and nitrogen in producing beard wheat in the highlands of Iran. Agric. Water. Manag. 2004;(65):225-236.
44. Yousif KH. Effect of humic acid, biofertilizer (EM-1) and application methods on growth, flowering and yield of cucumber (*Cucumis sativus L.*). M. Sc. Thesis. College of Agricultural. University of Duhok; 2011.

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